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Madan et al.

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(54) **METHODS AND APPARATUS FOR PROVIDING TRANSMIT POWER CONTROL FOR DEVICES ENGAGED IN D2D COMMUNICATIONS**

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(51) **Int. Cl.**

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H04W 52/24	(2009.01)
H04W 52/38	(2009.01)
H04W 52/14	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 52/242*** (2013.01); ***H04W 52/383*** (2013.01); ***H04W 52/386*** (2013.01); *H04W 52/146* (2013.01); *H04W 52/243* (2013.01); *Y02B 60/50* (2013.01)

(58) **Field of Classification Search**

CPC H04W 52/146; H04W 52/242; H04W 52/244; H04W 52/383

USPC 455/522

See application file for complete search history.

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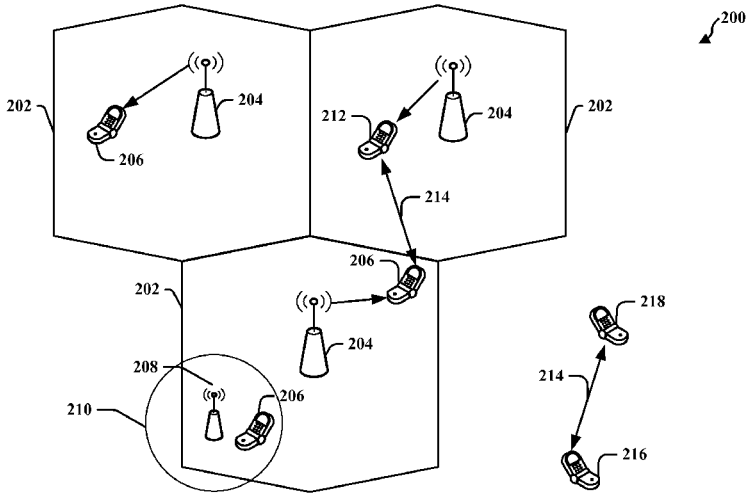
(57) **ABSTRACT**

A method, an apparatus, and a computer program product for wireless communication are provided for using power control to reduce potential interference to a macro eNB by a UE engaged in D2D communications. An eNB may be operable to generate a fractional power control parameter based on a macro eNB power saturation value and broadcast the factional power control parameter. A UE may be equipped to receive the factional power control parameter and determine whether the fractional power control parameter plus a path loss value between the UE and the macro eNB is less than a maximum power used for the D2D communications. The UE may reduce the maximum transmit power used for D2D communications when the fractional power control parameter plus a path loss value between the UE and the macro eNB is less than a maximum power used for the D2D communications.

22 Claims, 17 Drawing Sheets



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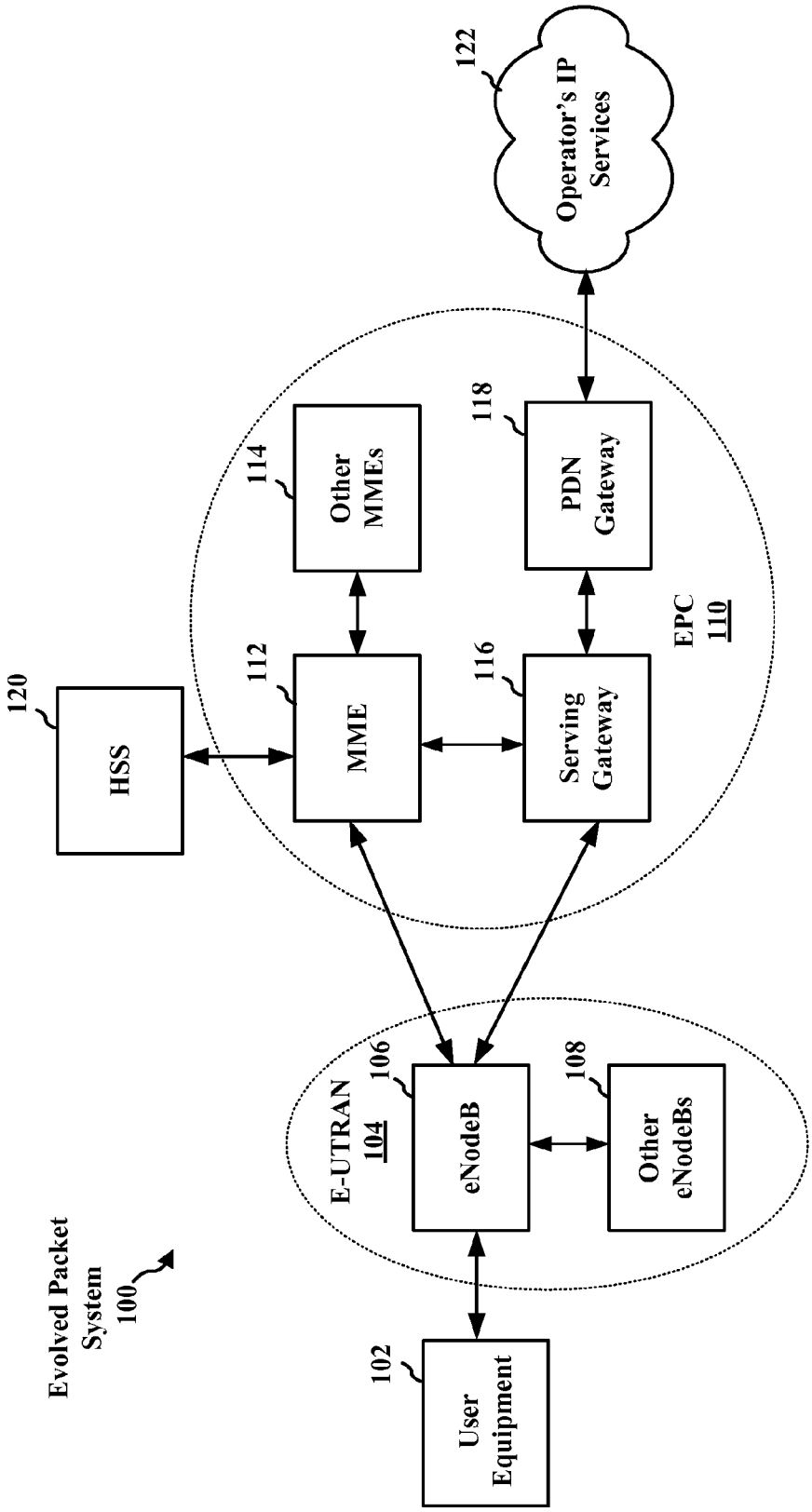
Evolved Packet System
100
User Equipment
102
E-UTRAN
104
eNodeB
106
Other eNodeBs
108
HSS
120
MME
112
Serving Gateway
116
Other MMEs
114
PDN Gateway
118
EPC
110
Operator's IP Services
122

FIG. 1

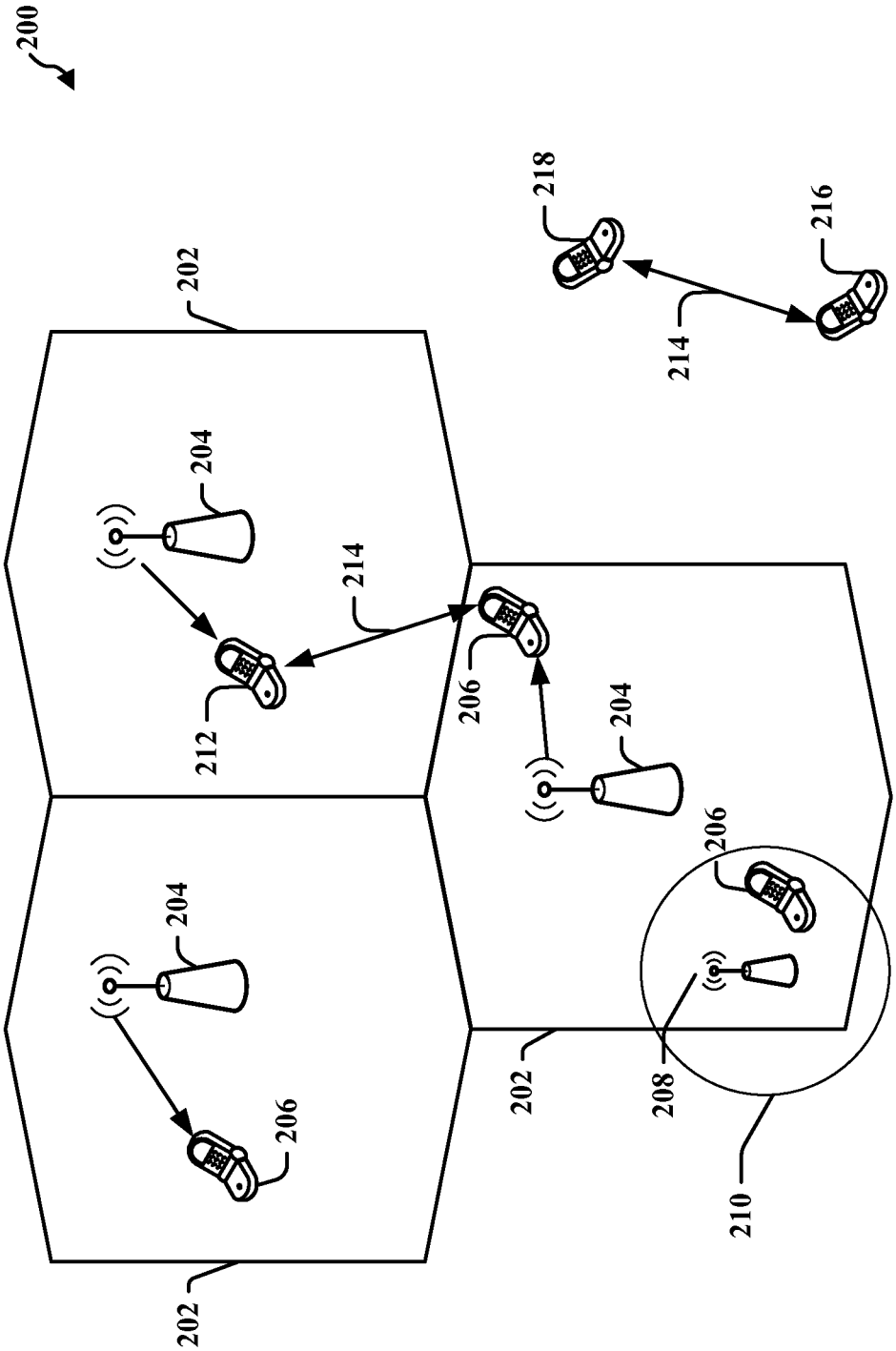

FIG. 2

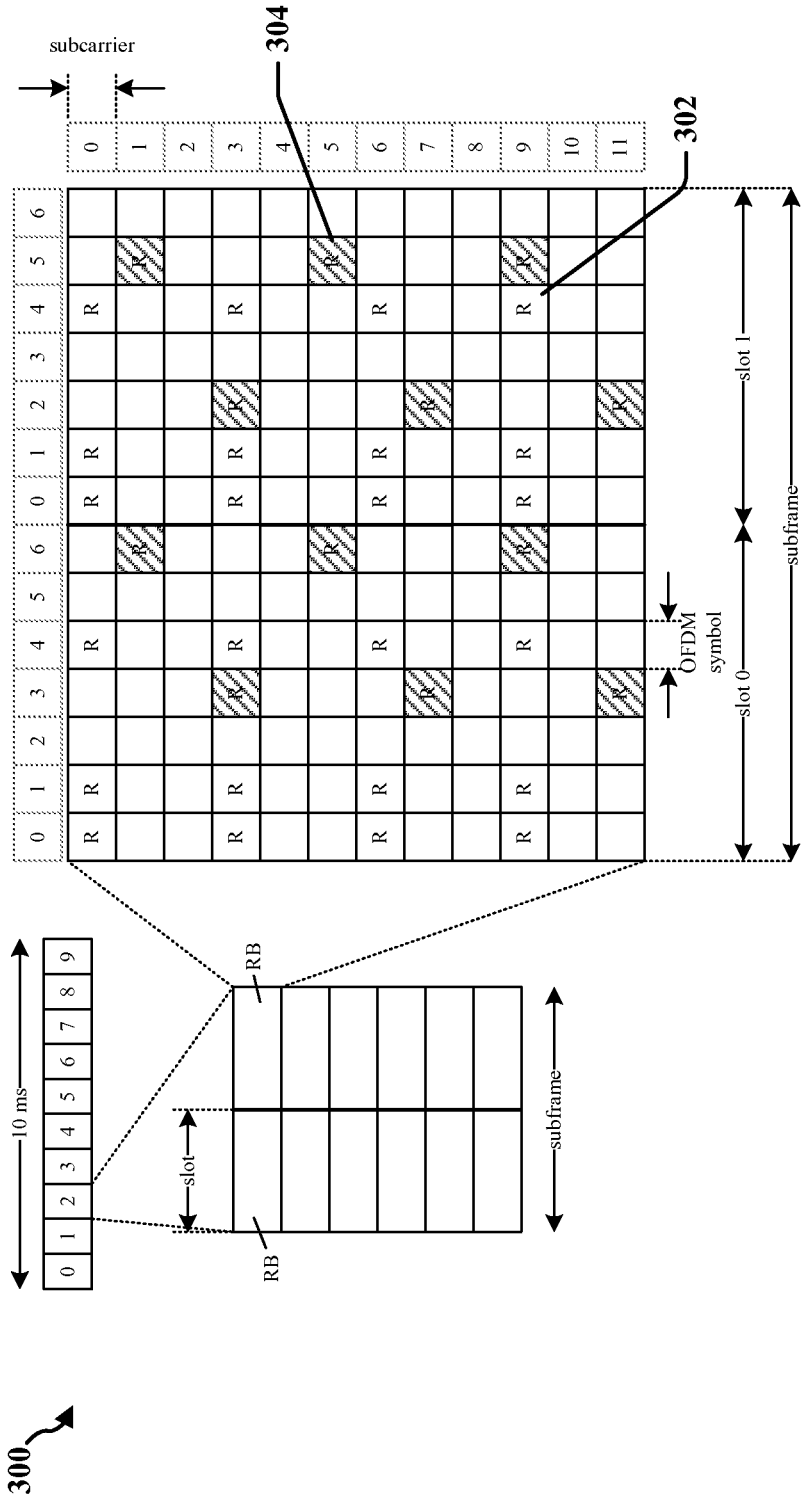
300
304
302
subcarrier
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6
R
slot 1
slot 0
subframe
OFDM symbol
10 ms
0 1 2 3 4 5 6 7 8 9
RB
slot
subframe

FIG. 3

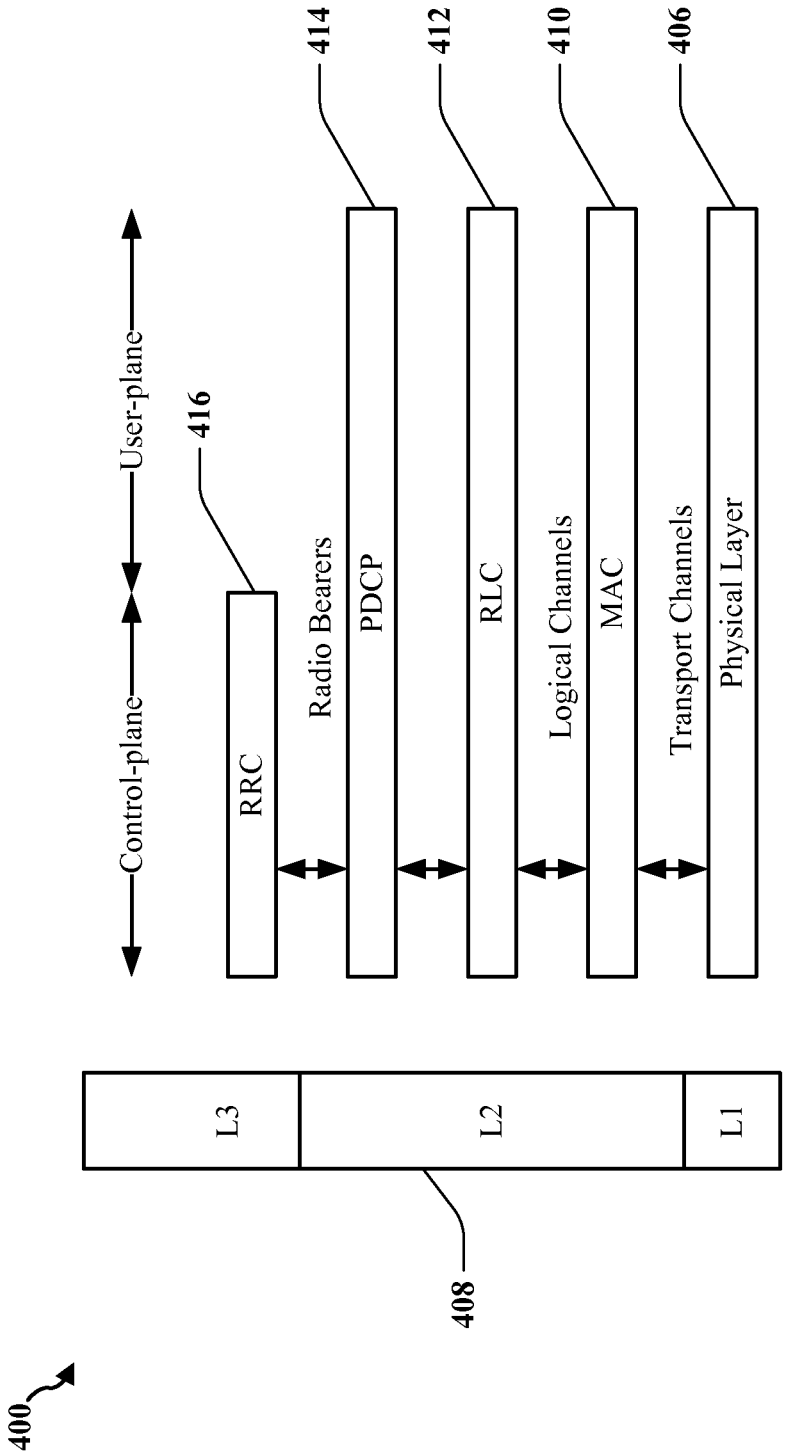
400
L3
L2
L1
408
RRC
416
Control-plane
User-plane
Radio Bearers
PDCP
414
RLC
412
Logical Channels
MAC
410
Transport Channels
Physical Layer
406

FIG. 4

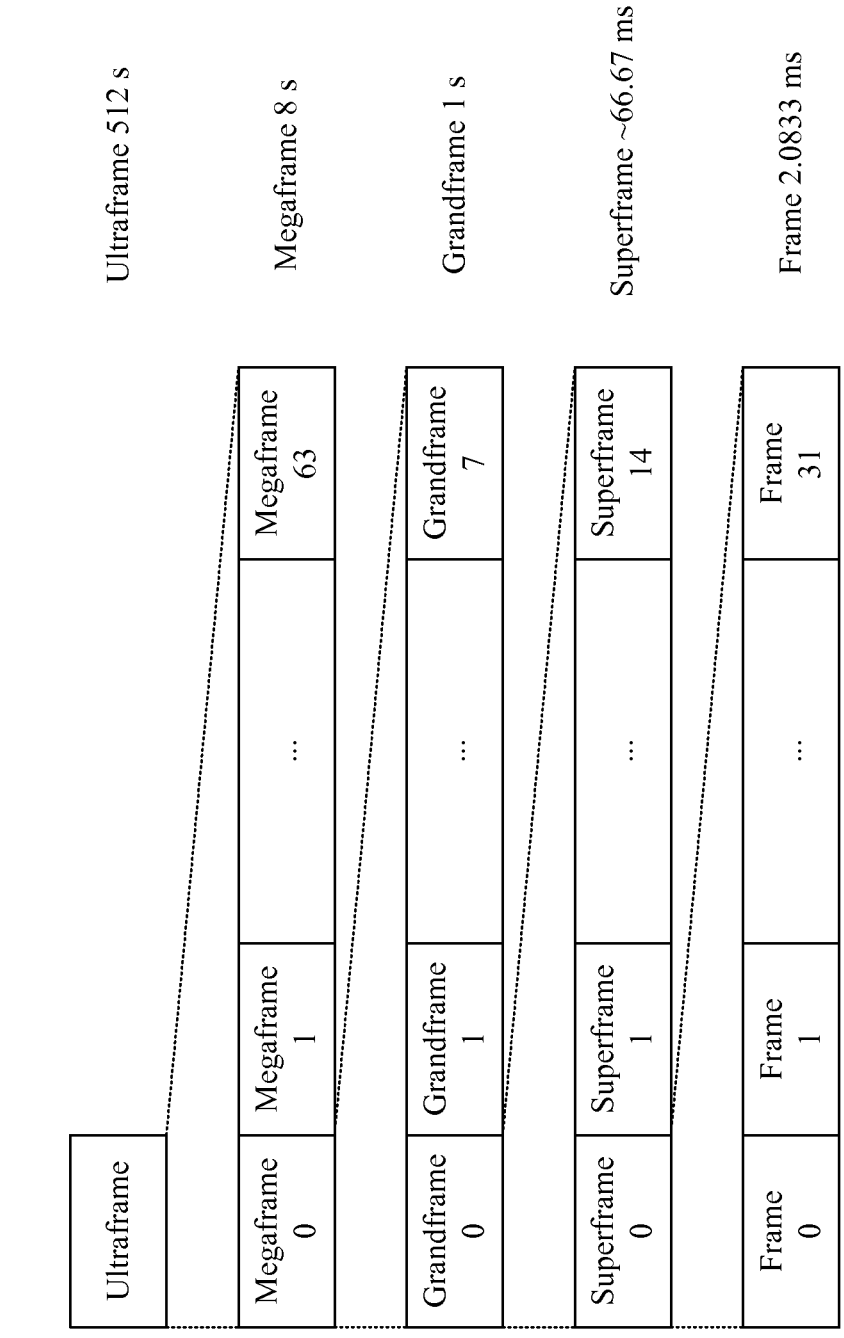
500
Ultraframe 512 s
Megaframe 8 s
Grandframe 1 s
Superframe ~66.67 ms
Frame 2.0833 ms
Ultraframe
Megaframe 0
Megaframe 1
...
Megaframe 63
Grandframe 0
Grandframe 1
...
Grandframe 7
Superframe 0
Superframe 1
...
Superframe 14
Frame 0
Frame 1
...
Frame 31

FIG. 5

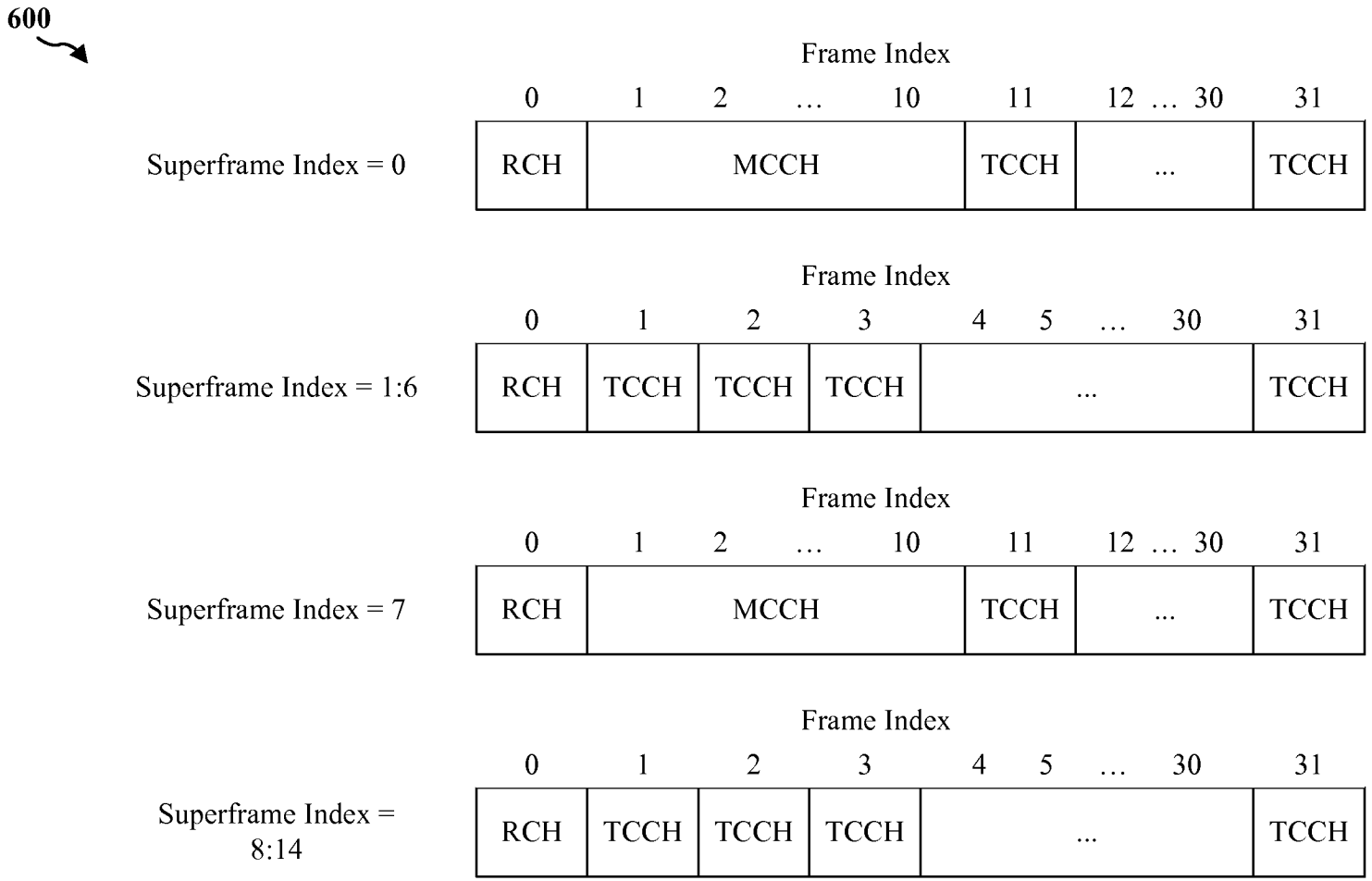
600
Frame Index
0 1 2 … 10 11 12 … 30 31
Superframe Index = 0
RCH
MCCH
TCCH
...
TCCH
Frame Index
0 1 2 3 4 5 … 30 31
Superframe Index = 1:6
RCH
TCCH
TCCH
TCCH
...
TCCH
Frame Index
0 1 2 … 10 11 12 … 30 31
Superframe Index = 7
RCH
MCCH
TCCH
...
TCCH
Frame Index
0 1 2 3 4 5 … 30 31
Superframe Index = 8:14
RCH
TCCH
TCCH
TCCH
...
TCCH

FIG. 6

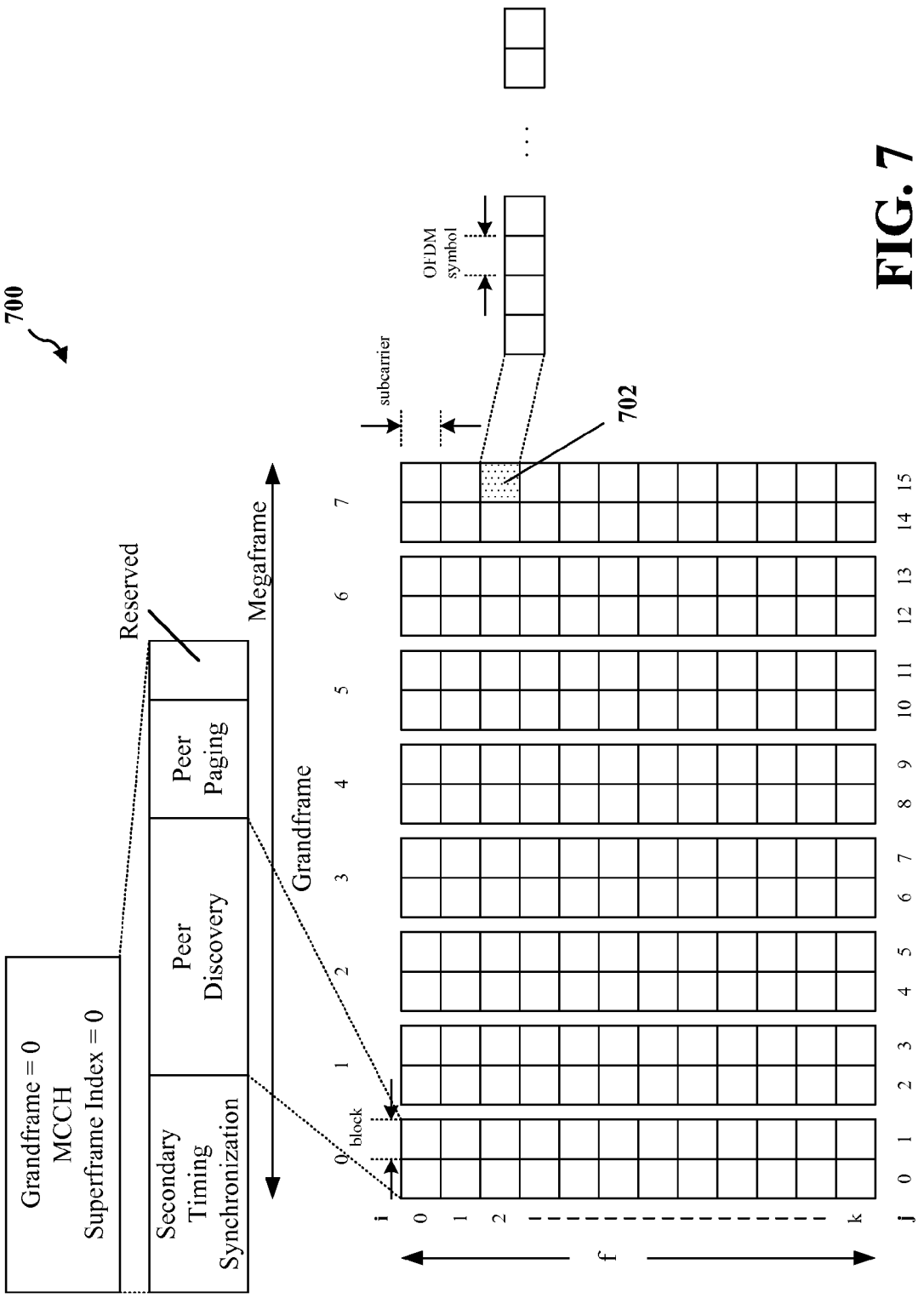
700
Grandframe = 0
MCCH
Superframe Index = 0
Secondary Timing Synchronization
Peer Discovery
Peer Paging
Reserved
Megaframe
Grandframe
block
subcarrier
OFDM symbol
702
i
j
k
f

FIG. 7

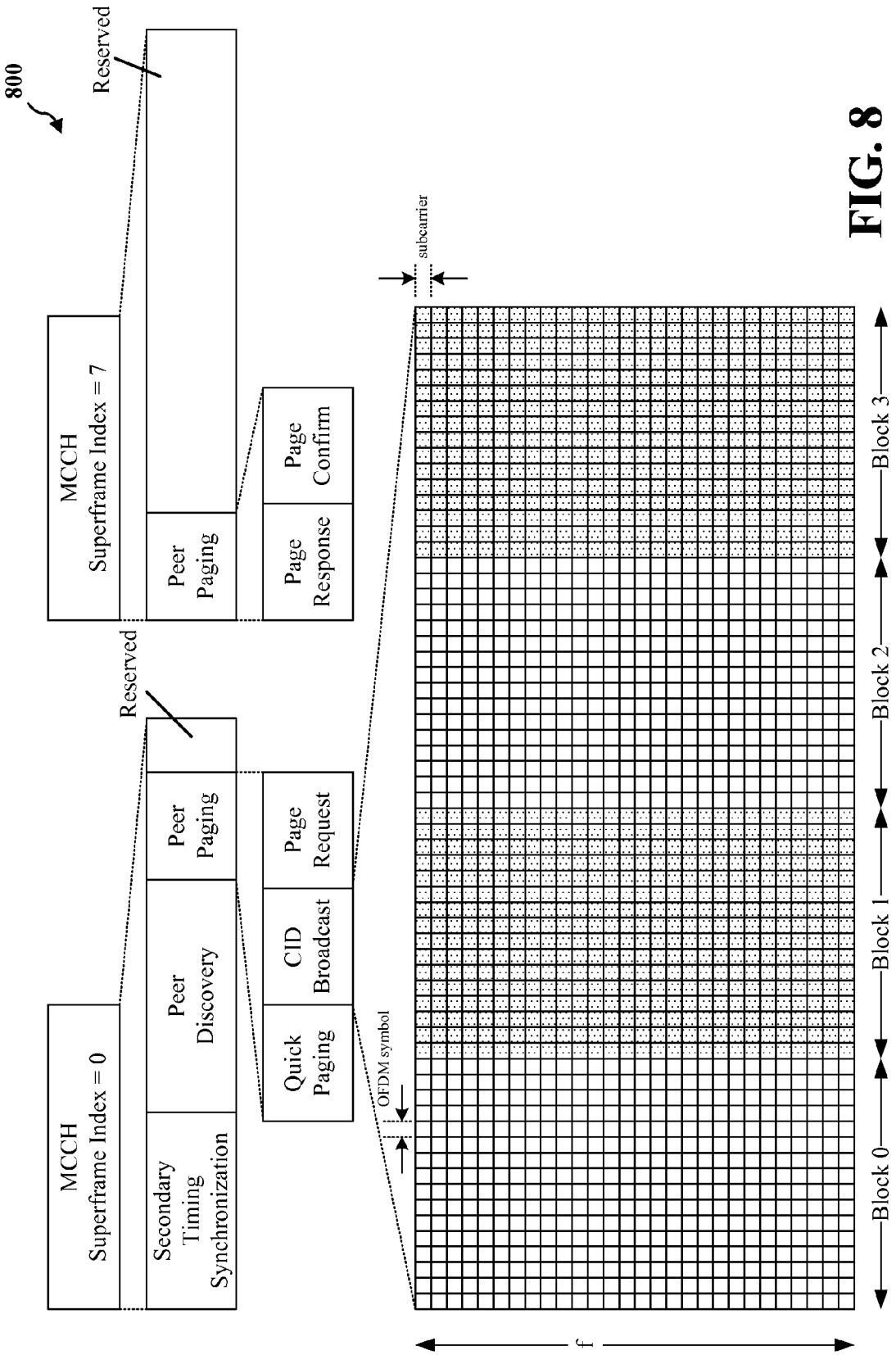
800
MCCH
Superframe Index = 0
Secondary
Timing
Synchronization
Peer
Discovery
Peer
Paging
Reserved
Quick
Paging
CID
Broadcast
Page
Request
MCCH
Superframe Index = 7
Peer
Paging
Reserved
Page
Response
Page
Confirm
OFDM symbol
subcarrier
Block 0
Block 1
Block 2
Block 3
f

FIG. 8

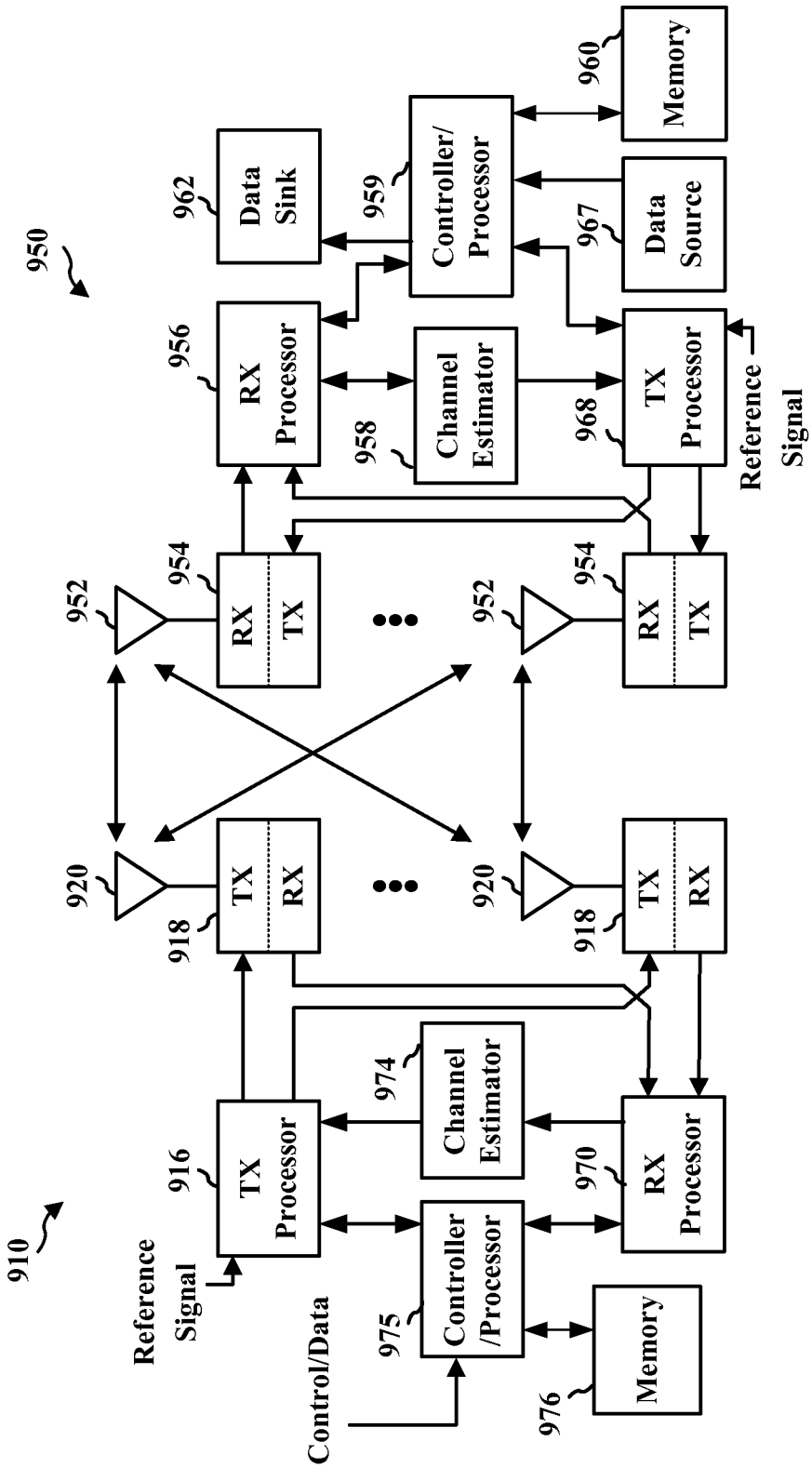
910
950
Reference Signal
Control/Data
916
TX Processor
975
Controller /Processor
974
Channel Estimator
976
Memory
970
RX Processor
918
TX
RX
920
952
954
RX
TX
956
RX Processor
958
Channel Estimator
959
Controller/ Processor
962
Data Sink
960
Memory
967
Data Source
968
TX Processor
Reference Signal

FIG. 9

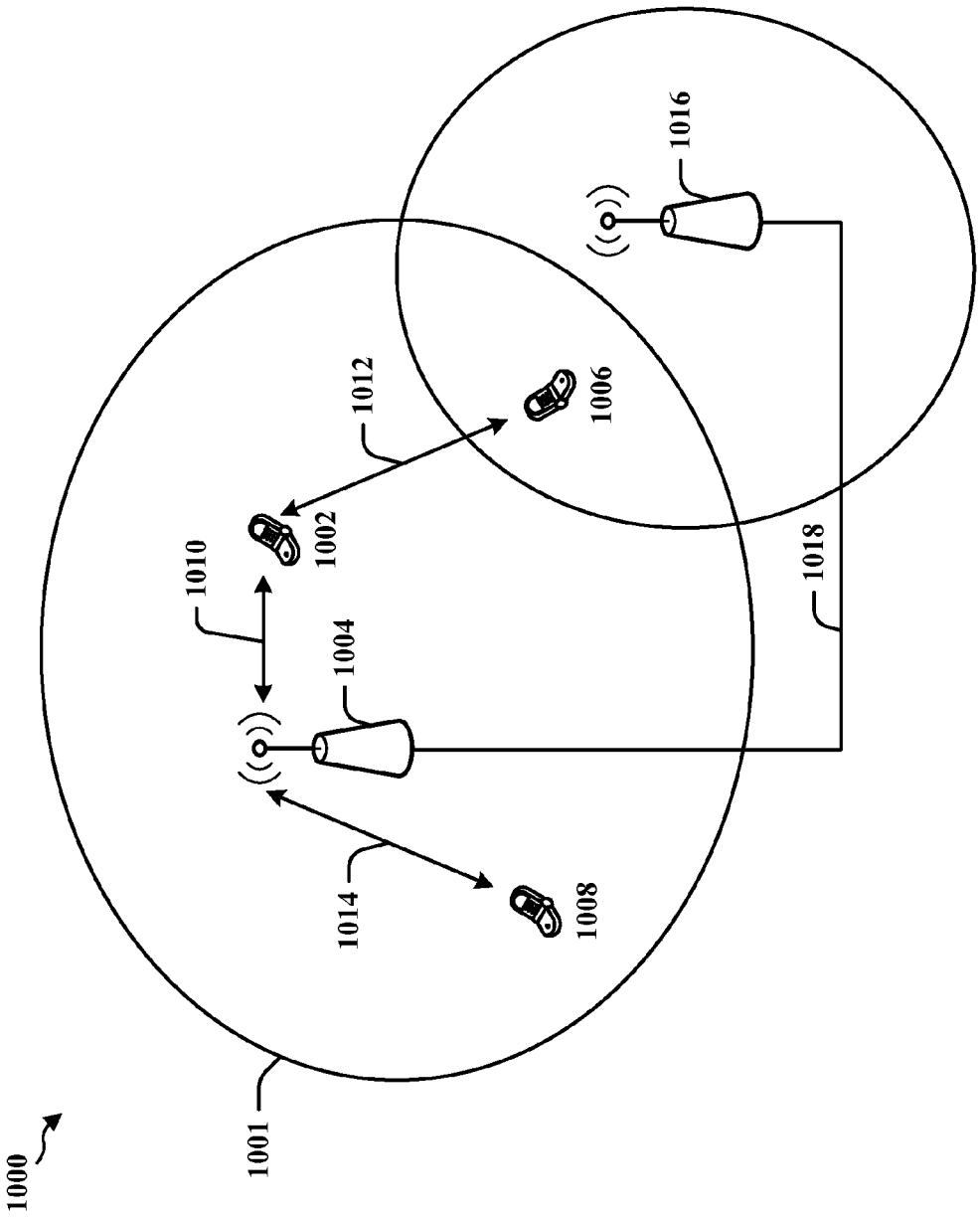

FIG. 10

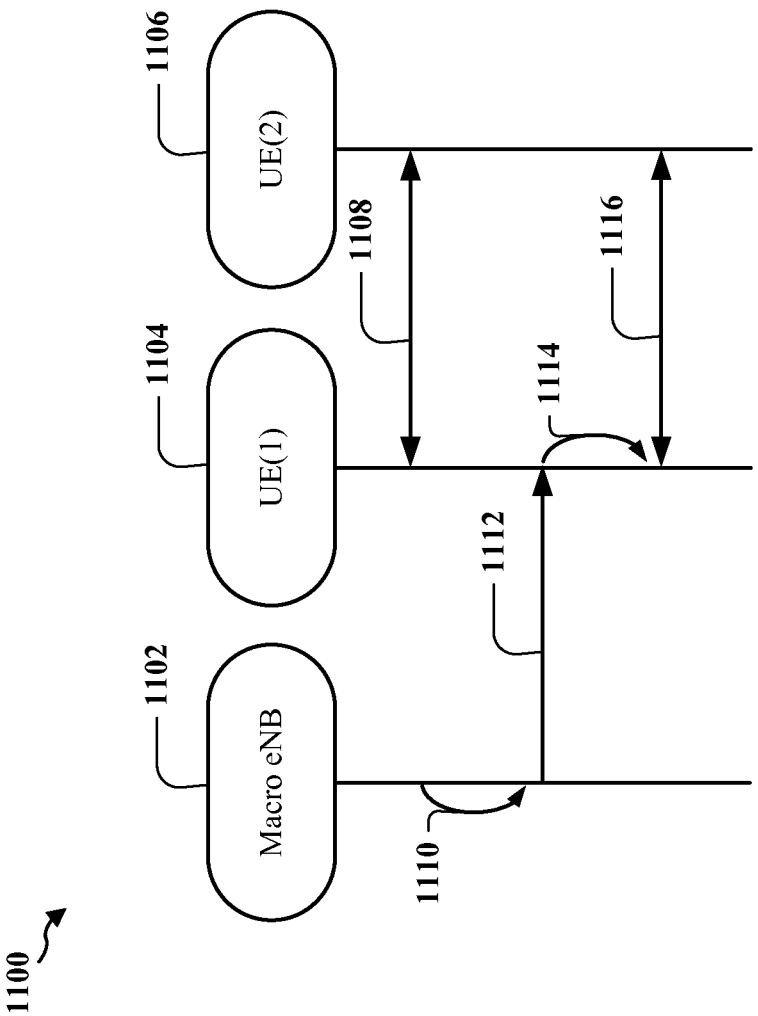
1100
1102
Macro eNB
1104
UE(1)
1106
UE(2)
1108
1110
1112
1114
1116

FIG. 11

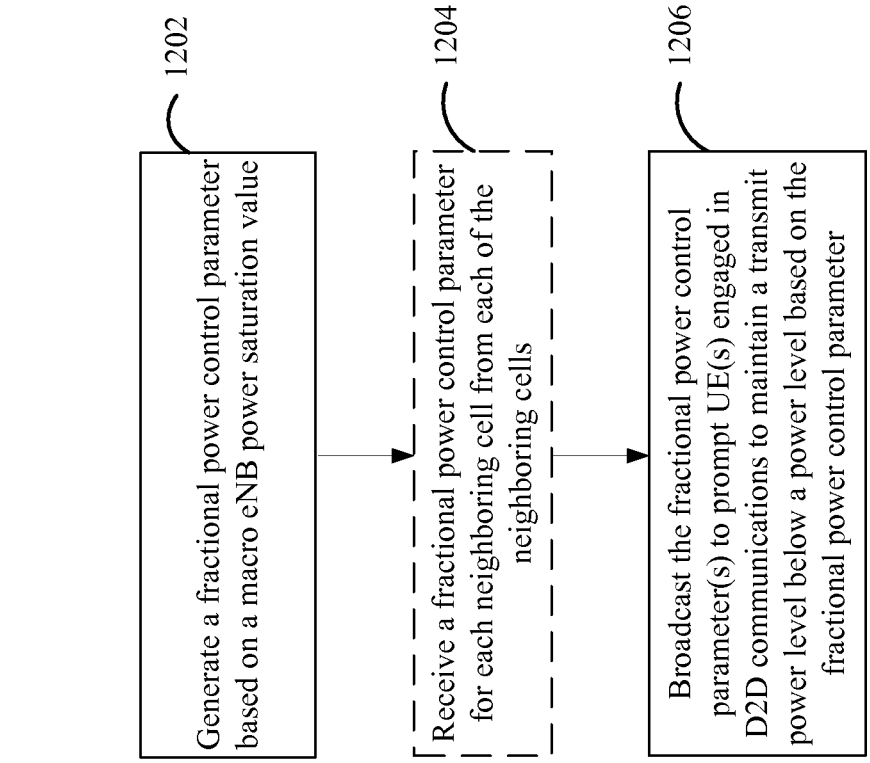
1200
1202
Generate a fractional power control parameter based on a macro eNB power saturation value
1204
Receive a fractional power control parameter for each neighboring cell from each of the neighboring cells
1206
Broadcast the fractional power control parameter(s) to prompt UE(s) engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter

FIG. 12

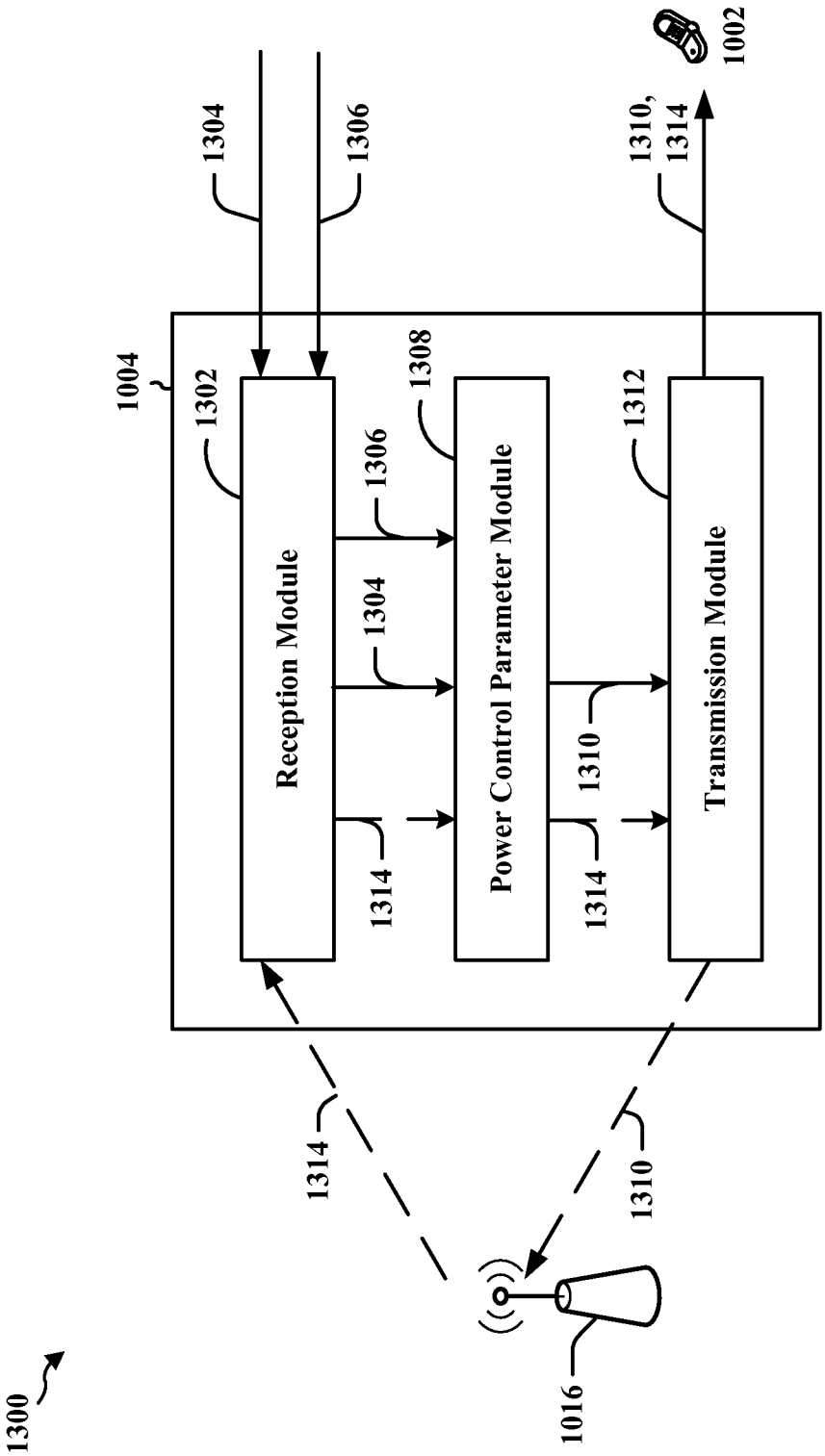
1300
1004
1302
Reception Module
1304
1306
1308
Power Control Parameter Module
1310
1312
Transmission Module
1310, 1314
1002
1314
1310
1016

FIG. 13

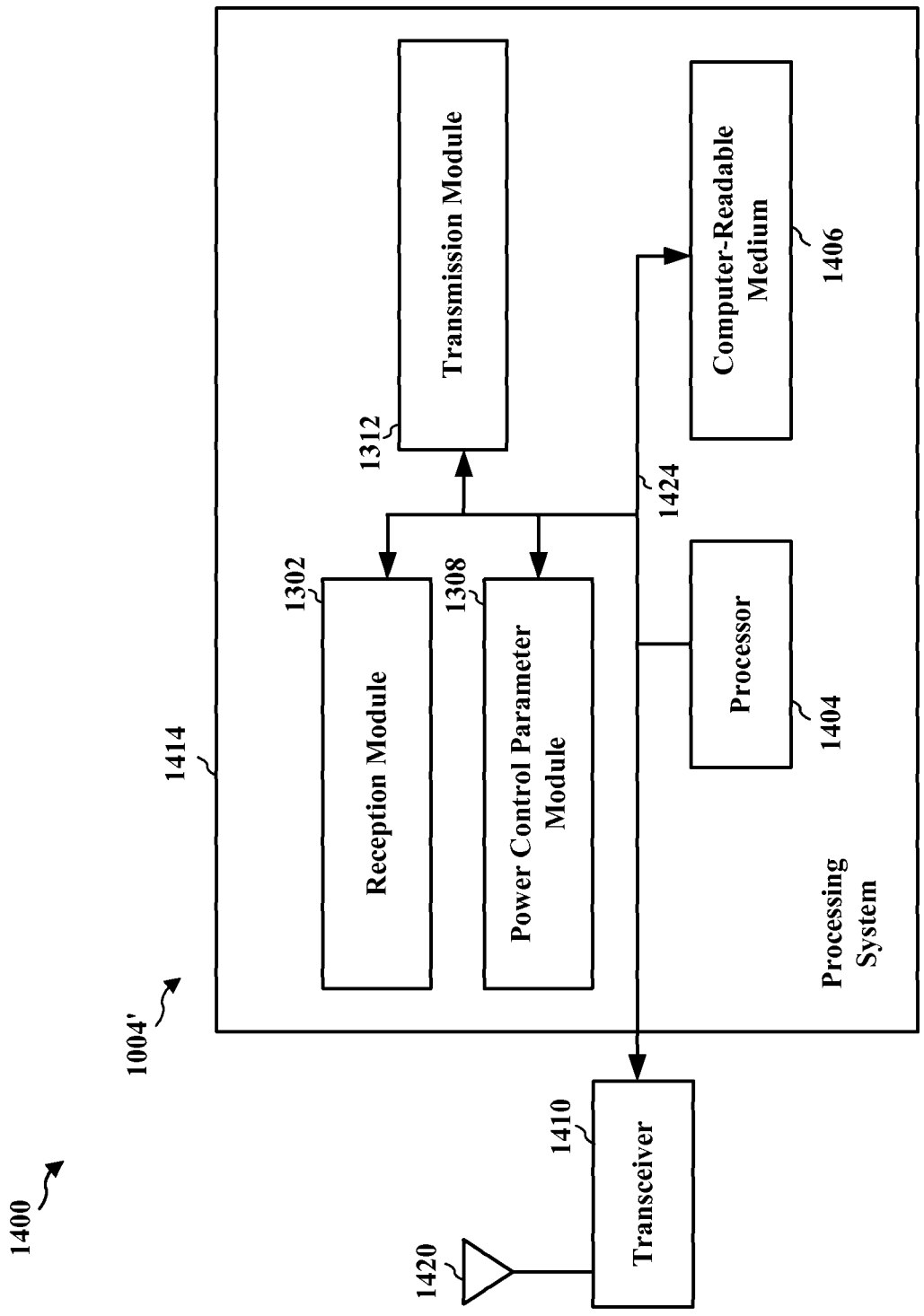
1400
1004'
1414
Processing System
Transmission Module
1312
Computer-Readable Medium
1406
1424
1302
Reception Module
1308
Power Control Parameter Module
Processor
1404
1410
Transceiver
1420

FIG. 14

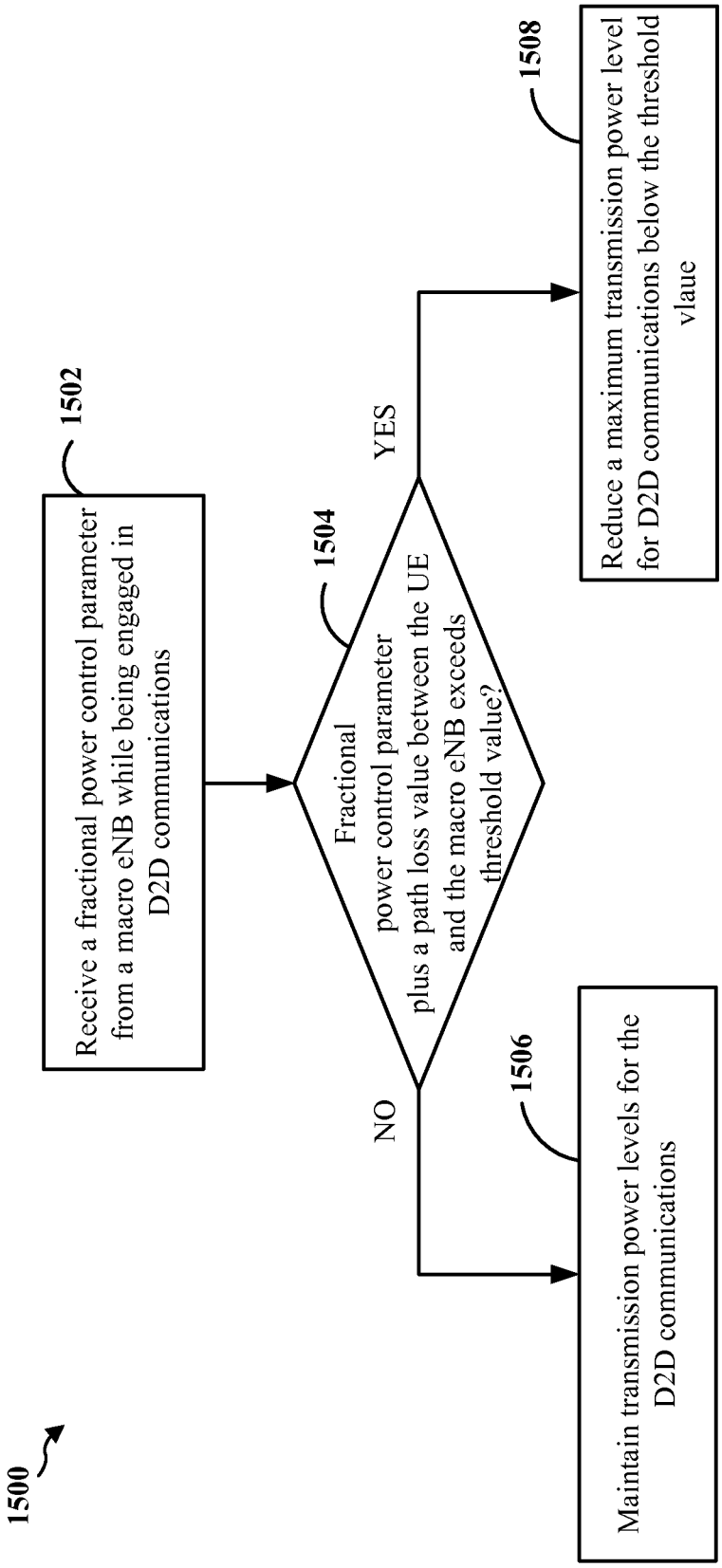
1500
1502
Receive a fractional power control parameter from a macro eNB while being engaged in D2D communications
1504
Fractional power control parameter plus a path loss value between the UE and the macro eNB exceeds threshold value?
YES
NO
1506
Maintain transmission power levels for the D2D communications
1508
Reduce a maximum transmission power level for D2D communications below the threshold vlaue

FIG. 15

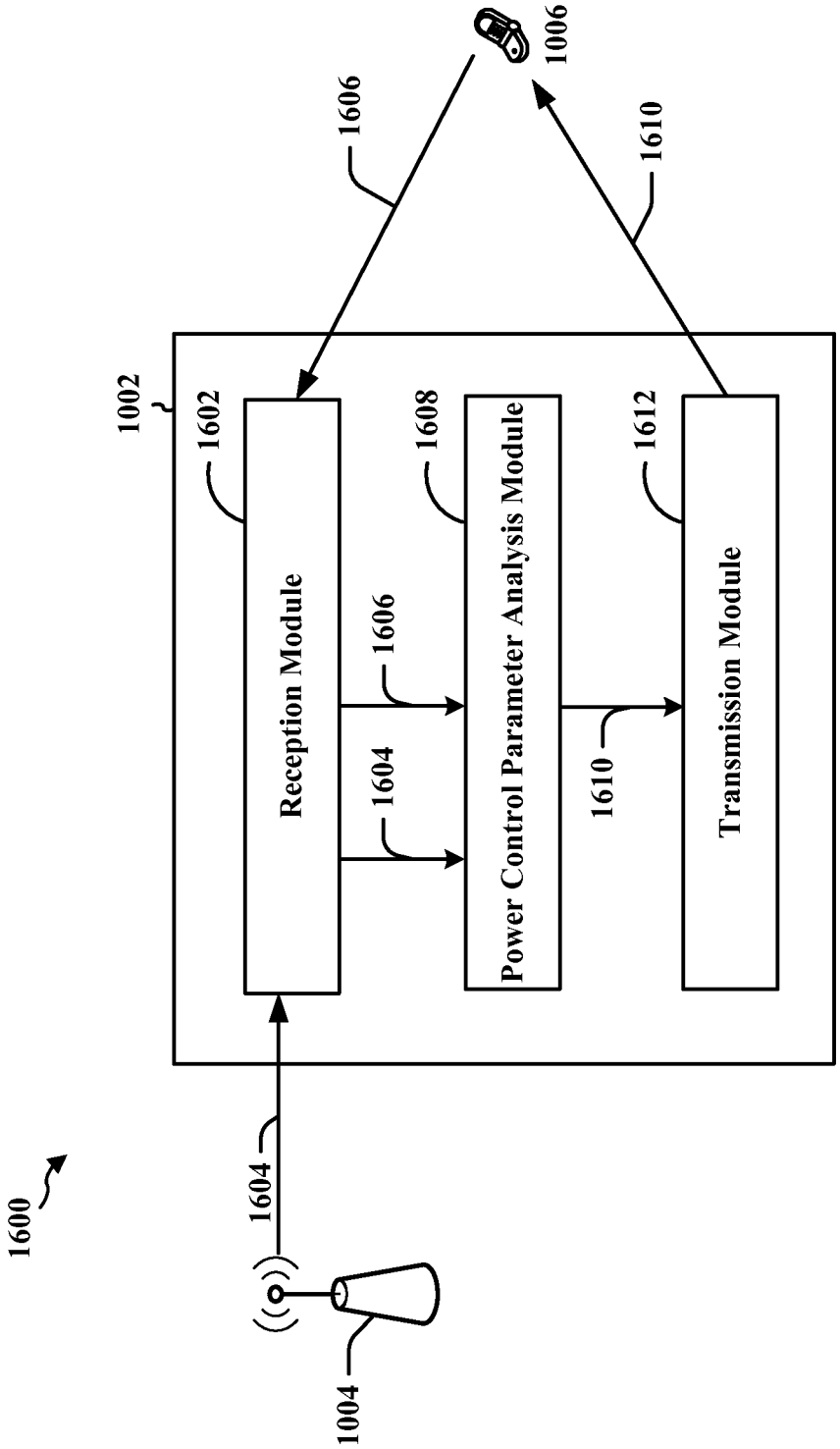
1600
1004
1604
1002
1602
Reception Module
1606
1604
1608
Power Control Parameter Analysis Module
1610
1612
Transmission Module
1606
1610
1006

FIG. 16

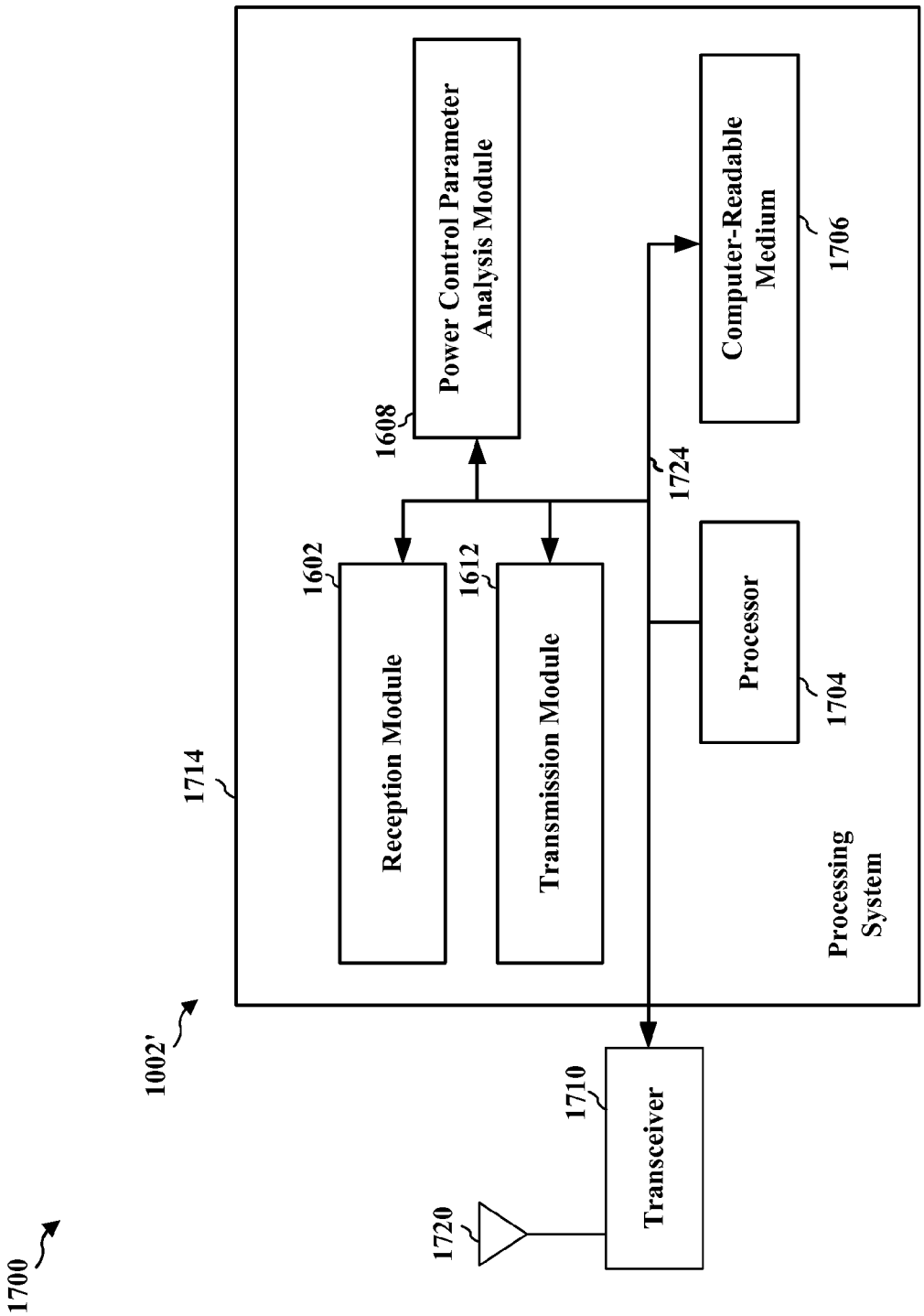
1700
1002'
1714
Reception Module
1602
Transmission Module
1612
Power Control Parameter Analysis Module
1608
Processor
1704
Computer-Readable Medium
1706
1724
Processing System
Transceiver
1710
1720

FIG. 17

METHODS AND APPARATUS FOR PROVIDING TRANSMIT POWER CONTROL FOR DEVICES ENGAGED IN D2D COMMUNICATIONS

BACKGROUND

1. Field

The present disclosure relates generally to communication systems, and more particularly, to a system for using power control to reduce potential interference to a macro evolved NodeB (eNB) by a user equipment (UE) engaged in device to device (D2D) communications.

2. Background

Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources (e.g., bandwidth, transmit power). Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency divisional multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

The wireless communications system may include a plurality UEs and a plurality of eNBs. The UEs may be associated with difference eNBs and the eNBs may be associated with different cells. A first UE associated with a first eNB in a first cell and a second UE associated with a second eNB in a second cell may be operable to communicate directly with each other using resources allocated for D2D communications. Devices in neighboring cells may be allocated different sets of resources for D2D communication. As such, a method and apparatus for determining available resources for D2D communication between UEs associated with different eNBs is desired.

SUMMARY

The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

In accordance with one or more aspects and corresponding disclosure thereof, various aspects are described in connection with using power control to reduce potential interference to a macro eNB by a UE engaged in D2D communications. In one example, an eNB may be operable to generate a fractional power control parameter based on a macro eNB power saturation value and broadcast the factional power control parameter so as to prompt any UEs engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter. A UE may be equipped to receive the factional power control parameter and determine whether the fractional power control parameter plus a path loss value between the UE and the macro eNB is less than a maximum power used for the D2D communications. The UE may reduce the maximum transmit power used for D2D communications when the fractional power control parameter plus a path loss value between the UE and the macro eNB is less than a maximum power used for the D2D communications.

According to related aspects, a method for using power control to reduce potential interference to a macro eNB by a UE engaged in D2D communications is provided. The method can include generating a fractional power control parameter based on a macro eNB power saturation value. Moreover, the method can include broadcasting the fractional power control parameter to prompt one or more UEs engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter.

Another aspect relates to a wireless communications apparatus. The wireless communications apparatus can include means for generating a fractional power control parameter based on a macro eNB power saturation value. Moreover, the wireless communications apparatus can include means for broadcasting the fractional power control parameter to prompt one or more UEs engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter.

Another aspect relates to a wireless communications apparatus. The apparatus can include a processing system configured to generate a fractional power control parameter based on a macro eNB power saturation value. Moreover, the processing system may be configured to broadcast the fractional power control parameter to prompt one or more UEs engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter.

Another aspect relates to a computer program product, which can have a computer-readable medium comprising code for generating a fractional power control parameter based on a macro eNB power saturation value. Moreover, the computer-readable medium can include code for broadcasting the fractional power control parameter to prompt one or more UEs engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter.

According to another related aspect, a method for using power control to reduce potential interference to a macro eNB by a UE engaged in D2D communications is provided. The method can include receiving, by a UE, a fractional power control parameter from a macro eNB while being engaged in D2D communications. Moreover, the method can include determining whether the a first value, defined by the fractional power control parameter plus a path loss value between the UE and the macro eNB, is less than a second value defined by a maximum power used for the D2D communications.

Another aspect relates to a wireless communications apparatus. The wireless communications apparatus can include means for receiving, by a UE, a fractional power control parameter from a macro eNB while being engaged in D2D communications. Moreover, the wireless communications apparatus can include means for determining whether the a first value, defined by the fractional power control parameter plus a path loss value between the UE and the macro eNB, is less than a second value defined by a maximum power used for the D2D communications.

Another aspect relates to a wireless communications apparatus. The apparatus can include a processing system configured to receive a fractional power control parameter from a macro eNB while being engaged in D2D communications. Moreover, the processing system may be configured to determine whether the a first value, defined by the fractional power control parameter plus a path loss value between the UE and

the macro eNB, is less than a second value defined by a maximum power used for the D2D communications.

Another aspect relates to a computer program product, which can have a computer-readable medium comprising code for receiving, by a UE, a fractional power control parameter from a macro eNB while being engaged in D2D communications. Moreover, the computer-readable medium can include code for determining whether the a first value, defined by the fractional power control parameter plus a path loss value between the UE and the macro eNB, is less than a second value defined by a maximum power used for the D2D communications.

To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating an example of a network architecture.

FIG. **2** is a diagram illustrating an example of an access network.

FIG. **3** is a diagram illustrating an example of a DL frame structure in LTE.

FIG. **4** is a diagram illustrating an example of a radio protocol architecture for the user and control planes.

FIG. **5** is a diagram illustrating an exemplary time structure for peer-to-peer communication between the wireless devices.

FIG. **6** is a diagram illustrating the channels in each frame of superframes in one grandframe.

FIG. **7** is a diagram illustrating an operation timeline of a miscellaneous channel and a structure of a peer discovery channel.

FIG. **8** is a diagram illustrating an operation timeline of a miscellaneous channel and a structure of a connection identifier broadcast.

FIG. **9** is a diagram illustrating an example of an evolved Node B and user equipment in an access network.

FIG. **10** is a diagram illustrating an example of an access network in which D2D communications may be performed according to an aspect.

FIG. **11** is a call flow diagram of a communications an access network according to an aspect.

FIG. **12** is a flow chart of a method of wireless communication.

FIG. **13** is a conceptual data flow diagram illustrating the data flow between different modules/means/components in an exemplary apparatus.

FIG. **14** is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

FIG. **15** is a flow chart of a method of wireless communication.

FIG. **16** is a conceptual data flow diagram illustrating the data flow between different modules/means/components in an exemplary apparatus.

FIG. **17** is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

DETAILED DESCRIPTION

The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, modules, components, circuits, steps, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

By way of example, an element, or any portion of an element, or any combination of elements may be implemented with a "processing system" that includes one or more processors. Examples of processors include microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

Accordingly, in one or more exemplary embodiments, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

FIG. **1** is a diagram illustrating an LTE network architecture **100**. The LTE network architecture **100** may be referred to as an Evolved Packet System (EPS) **100**. The EPS **100** may include one or more user equipment (UE) **102**, an Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) **104**,

an Evolved Packet Core (EPC) **110**, a Home Subscriber Server (HSS) **120**, and an Operator's IP Services **122**. The EPS can interconnect with other access networks, but for simplicity those entities/interfaces are not shown. As shown, the EPS provides packet-switched services, however, as those skilled in the art will readily appreciate, the various concepts presented throughout this disclosure may be extended to networks providing circuit-switched services.

The E-UTRAN includes the evolved Node B (eNB) **106** and other eNBs **108**. The eNB **106** provides user and control planes protocol terminations toward the UE **102**. The eNB **106** may be connected to the other eNBs **108** via an X2 interface (e.g., backhaul). The eNB **106** may also be referred to as a base station, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), or some other suitable terminology. The eNB **106** provides an access point to the EPC **110** for a UE **102**. Examples of UEs **102** include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, or any other similar functioning device. The UE **102** may also be referred to by those skilled in the art as a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology.

The eNB **106** is connected by an S1 interface to the EPC **110**. The EPC **110** includes a Mobility Management Entity (MME) **112**, other MMEs **114**, a Serving Gateway **116**, and a Packet Data Network (PDN) Gateway **118**. The MME **112** is the control node that processes the signaling between the UE **102** and the EPC **110**. Generally, the MME **112** provides bearer and connection management. All user IP packets are transferred through the Serving Gateway **116**, which itself is connected to the PDN Gateway **118**. The PDN Gateway **118** provides UE IP address allocation as well as other functions. The PDN Gateway **118** is connected to the Operator's IP Services **122**. The Operator's IP Services **122** may include the Internet, the Intranet, an IP Multimedia Subsystem (IMS), and a PS Streaming Service (PSS).

FIG. **2** is a diagram illustrating an example of an access network **200** in an LTE network architecture. In this example, the access network **200** is divided into a number of cellular regions (cells) **202**. One or more lower power class eNBs **208** may have cellular regions **210** that overlap with one or more of the cells **202**. A lower power class eNB **208** may be referred to as a remote radio head (RRH). The lower power class eNB **208** may be a femto cell (e.g., home eNB (HeNB)), pico cell, or micro cell. The macro eNBs **204** are each assigned to a respective cell **202** and are configured to provide an access point to the EPC **110** for all the UEs **206** in the cells **202**. There is no centralized controller in this example of an access network **200**, but a centralized controller may be used in alternative configurations. The eNBs **204** are responsible for all radio related functions including radio bearer control, admission control, mobility control, scheduling, security, and connectivity to the serving gateway **116**.

Further, some of the wireless devices **206**, **212**, **216**, **218** may communicate together in peer-to-peer communication **214**, some may communicate with the base station **204**, and some may do both. For example, as shown in FIG. **2**, the wireless devices **216**, **218** may be in peer-to-peer communication **214** and the wireless devices **206**, **212** may be in peer-to-peer communication **214**. The wireless devices **206**, **212** may also be in communication with the base station **204**.

The modulation and multiple access scheme employed by the access network **200** may vary depending on the particular telecommunications standard being deployed. In LTE applications, OFDM is used on the DL and SC-FDMA is used on the UL to support both frequency division duplexing (FDD) and time division duplexing (TDD). As those skilled in the art will readily appreciate from the detailed description to follow, the various concepts presented herein are well suited for LTE applications. However, these concepts may be readily extended to other telecommunication standards employing other modulation and multiple access techniques. By way of example, these concepts may be extended to Evolution-Data Optimized (EV-DO) or Ultra Mobile Broadband (UMB). EV-DO and UMB are air interface standards promulgated by the 3rd Generation Partnership Project 2 (3GPP2) as part of the CDMA2000 family of standards and employs CDMA to provide broadband Internet access to mobile stations. These concepts may also be extended to Universal Terrestrial Radio Access (UTRA) employing Wideband-CDMA (W-CDMA) and other variants of CDMA, such as TD-SCDMA; Global System for Mobile Communications (GSM) employing TDMA; and Evolved UTRA (E-UTRA), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, and Flash-OFDM employing OFDMA. UTRA, E-UTRA, UMTS, LTE and GSM are described in documents from the 3GPP organization. CDMA2000 and UMB are described in documents from the 3GPP2 organization. The actual wireless communication standard and the multiple access technology employed will depend on the specific application and the overall design constraints imposed on the system.

The eNBs **204** may have multiple antennas supporting MIMO technology. The use of MIMO technology enables the eNBs **204** to exploit the spatial domain to support spatial multiplexing, beamforming, and transmit diversity. Spatial multiplexing may be used to transmit different streams of data simultaneously on the same frequency. The data steams may be transmitted to a single UE **206** to increase the data rate or to multiple UEs **206** to increase the overall system capacity. This is achieved by spatially precoding each data stream (i.e., applying a scaling of an amplitude and a phase) and then transmitting each spatially precoded stream through multiple transmit antennas on the DL. The spatially precoded data streams arrive at the UE(s) **206** with different spatial signatures, which enables each of the UE(s) **206** to recover the one or more data streams destined for that UE **206**. On the UL, each UE **206** transmits a spatially precoded data stream, which enables the eNB **204** to identify the source of each spatially precoded data stream.

Spatial multiplexing is generally used when channel conditions are good. When channel conditions are less favorable, beamforming may be used to focus the transmission energy in one or more directions. This may be achieved by spatially precoding the data for transmission through multiple antennas. To achieve good coverage at the edges of the cell, a single stream beamforming transmission may be used in combination with transmit diversity.

In the detailed description that follows, various aspects of an access network will be described with reference to a MIMO system supporting OFDM on the DL. OFDM is a spread-spectrum technique that modulates data over a number of subcarriers within an OFDM symbol. The subcarriers are spaced apart at precise frequencies. The spacing provides "orthogonality" that enables a receiver to recover the data from the subcarriers. In the time domain, a guard interval

(e.g., cyclic prefix) may be added to each OFDM symbol to combat inter-OFDM-symbol interference. The UL may use SC-FDMA in the form of a DFT-spread OFDM signal to compensate for high peak-to-average power ratio (PAPR).

FIG. **3** is a diagram **300** illustrating an example of a DL frame structure in LTE. A frame (10 ms) may be divided into 10 equally sized sub-frames. Each sub-frame may include two consecutive time slots. A resource grid may be used to represent two time slots, each time slot including a resource block. The resource grid is divided into multiple resource elements. In LTE, a resource block contains 12 consecutive subcarriers in the frequency domain and, for a normal cyclic prefix in each OFDM symbol, 7 consecutive OFDM symbols in the time domain, or 84 resource elements. For an extended cyclic prefix, a resource block contains 6 consecutive OFDM symbols in the time domain and has 72 resource elements. Some of the resource elements, as indicated as R **302**, **304**, include DL reference signals (DL-RS). The DL-RS include Cell-specific RS (CRS) (also sometimes called common RS) **302** and UE-specific RS (UE-RS) **304**. UE-RS **304** are transmitted only on the resource blocks upon which the corresponding physical DL shared channel (PDSCH) is mapped. The number of bits carried by each resource element depends on the modulation scheme. Thus, the more resource blocks that a UE receives and the higher the modulation scheme, the higher the data rate for the UE.

FIG. **4** is a diagram **400** illustrating an example of a radio protocol architecture for the user and control planes in LTE. The radio protocol architecture for the UE and the eNB is shown with three layers: Layer 1, Layer 2, and Layer 3. Layer 1 (L1 layer) is the lowest layer and implements various physical layer signal processing functions. The L1 layer will be referred to herein as the physical layer **406**. Layer 2 (L2 layer) **408** is above the physical layer **406** and is responsible for the link between the UE and eNB over the physical layer **406**.

In the user plane, the L2 layer **408** includes a media access control (MAC) sublayer **410**, a radio link control (RLC) sublayer **412**, and a packet data convergence protocol (PDCP) **414** sublayer, which are terminated at the eNB on the network side. Although not shown, the UE may have several upper layers above the L2 layer **408** including a network layer (e.g., IP layer) that is terminated at the PDN gateway **118** on the network side, and an application layer that is terminated at the other end of the connection (e.g., far end UE, server, etc.).

The PDCP sublayer **414** provides multiplexing between different radio bearers and logical channels. The PDCP sublayer **414** also provides header compression for upper layer data packets to reduce radio transmission overhead, security by ciphering the data packets, and handover support for UEs between eNBs. The RLC sublayer **412** provides segmentation and reassembly of upper layer data packets, retransmission of lost data packets, and reordering of data packets to compensate for out-of-order reception due to hybrid automatic repeat request (HARQ). The MAC sublayer **410** provides multiplexing between logical and transport channels. The MAC sublayer **410** is also responsible for allocating the various radio resources (e.g., resource blocks) in one cell among the UEs. The MAC sublayer **410** is also responsible for HARQ operations.

In the control plane, the radio protocol architecture for the UE and eNB is substantially the same for the physical layer **406** and the L2 layer **408** with the exception that there is no header compression function for the control plane. The control plane also includes a radio resource control (RRC) sublayer **416** in Layer 3 (L3 layer). The RRC sublayer **416** is responsible for obtaining radio resources (i.e., radio bearers) and for configuring the lower layers using RRC signaling between the eNB and the UE.

FIG. **5** is a diagram **500** illustrating an exemplary time structure for peer-to-peer communication between the wireless devices. An ultraframe is 512 seconds and includes 64 megaframes. Each megaframe is eight seconds and includes eight grandframes. Each grandframe is one second and includes 15 superframes. Each superframe is approximately 66.67 ms and includes 32 frames. Each frame is 2.0833 ms.

FIG. **6** is a diagram **600** illustrating the channels in each frame of superframes in one grandframe. In a first superframe (with index 0), frame 0 is a reserved channel (RCH), frames 1-10 are each a miscellaneous channel (MCCH), and frames 11-31 are each a traffic channel (TCCH). In the 2nd through 7th superframes (with index 1:6), frame 0 is a RCH and frames 1-31 are each a TCCH. In an 8th superframe (with index 7), frame 0 is a RCH, frames 1-10 are each a MCCH, and frames 11-31 are each a TCCH. In the 9th through 15th superframes (with index 8:14), frame 0 is a RCH and frames 1-31 are each a TCCH. The MCCH of superframe index 0 includes a secondary timing synchronization channel, a peer discovery channel, a peer page channel, and a reserved slot. The MCCH of superframe index 7 includes a peer page channel and reserved slots. The TCCH includes connection scheduling, a pilot, channel quality indicator (CQI) feedback, a data segment, and an acknowledgement (ACK).

FIG. **7** is a diagram **700** illustrating an operation timeline of the MCCH and an exemplary structure of a peer discovery channel. As discussed in relation to FIG. **6**, the MCCH of superframe index 0 includes a secondary timing synchronization channel, a peer discovery channel, a peer paging channel, and a reserved slot. The peer discovery channel may be divided into subchannels. For example, the peer discovery channel may be divided into a long range peer discovery channel, a medium range peer discovery channel, a short range peer discovery channel, and other channels. Each of the subchannels may include a plurality of blocks/resources for communicating peer discovery information. Each block may include a plurality of orthogonal frequency-division multiplexing (OFDM) symbols (e.g., 72) at the same subcarrier. FIG. **7** provides an example of a subchannel (e.g., short range peer discovery channel) including blocks in one megaframe, which includes the MCCH superframe index 0 of grandframes 0 through 7. Different sets of blocks correspond to different peer discovery resource identifiers (PDRIDs). For example, one PDRID may correspond to one of the blocks in the MCCH superframe index 0 of one grandframe in the megaframe.

Upon power up, a wireless device listens to the peer discovery channel for a period of time (e.g., two megaframes) and selects a PDRID based on a determined energy on each of the PDRIDs. For example, a wireless device may select a PDRID corresponding to block **702** (i=2 and j=15) in a first megaframe of an ultraframe. The particular PDRID may map to other blocks in other megaframes of the ultraframe due to hopping. In blocks associated with the selected PDRID, the wireless device transmits its peer discovery signal. In blocks unassociated with the selected PDRID, the wireless device listens for peer discovery signals transmitted by other wireless devices.

The wireless device may also reselect a PDRID if the wireless device detects a PDRID collision. That is, a wireless device may listen rather than transmit on its available peer discovery resource in order to detect an energy on the peer discovery resource corresponding to its PDRID. The wireless device may also detect energies on other peer discovery

resources corresponding to other PDRIDs. The wireless device may reselect a PDRID based on the determined energy on the peer discovery resource corresponding to its PDRID and the detected energies on the other peer discovery resources corresponding to other PDRIDs.

FIG. **8** is a diagram **800** illustrating an operation timeline of the MCCH and a structure of a connection identifier (CID) broadcast. As discussed in relation to FIG. **6**, the MCCH of superframe index 0 includes a secondary timing synchronization channel, a peer discovery channel, a peer paging channel, and a reserved slot. The peer paging channel in the MCCH of superframe index 0 includes a quick paging channel, a CID broadcast channel, and a page request channel. The MCCH of superframe index 7 includes a peer paging channel and a reserved slot. The peer paging channel in the MCCH of superframe index 7 includes a page response channel and a page confirm channel. The CID broadcast channel provides a distributed protocol for CID allocations for new connections, provides a mechanism for CID collision detection, and provides a wireless device evidence that its link connection with a communication peer still exists.

The structure of the CID broadcast consists of four blocks, each of which contains a plurality of resource elements, i.e., a plurality of subcarriers in the frequency domain and OFDM symbols in the time domain. Each of the four blocks spans a plurality of subcarriers (e.g., 28 subcarriers) and includes 16 OFDM symbols. One resource element (or tone) corresponds to one subcarrier and one OFDM symbol.

For each CID, a pair of resource elements in adjacent OFDM symbols is allocated in each of the four blocks for the CID broadcast. In a pair of adjacent resource elements, a first resource element carries an energy proportional to a power used to transmit in the TCCH and a second resource element carries an energy inversely proportional to a power received in the TCCH. For a given CID, each pair of resource elements has a fixed OFDM symbol position and a varying subcarrier within the block that varies each grandframe. In any given link, the wireless device that initiated the link randomly selects a block from Block **0** and Block **2** for the CID broadcast and the other wireless device in the link randomly selects a block from Block **1** and Block **3** for the CID broadcast. As such, for a particular CID, only half of the allocated resources are utilized by a link with that CID. Due to the random selection of a block, a first wireless device in a link with a second wireless device will be able to detect a CID collision when a third wireless device or a fourth wireless device in a different link transmits a CID broadcast using a block different than the block selected by the first wireless device or the second wireless device.

FIG. **9** is a block diagram of an eNB **910** in communication with a UE **950** in an access network. In the DL, upper layer packets from the core network are provided to a controller/processor **975**. The controller/processor **975** implements the functionality of the L2 layer. In the DL, the controller/processor **975** provides header compression, ciphering, packet segmentation and reordering, multiplexing between logical and transport channels, and radio resource allocations to the UE **950** based on various priority metrics. The controller/processor **975** is also responsible for HARQ operations, retransmission of lost packets, and signaling to the UE **950**.

The transmit (TX) processor **916** implements various signal processing functions for the L1 layer (i.e., physical layer). The signal processing functions includes coding and interleaving to facilitate forward error correction (FEC) at the UE **950** and mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols are then split into parallel streams. Each stream is then mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator **974** may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE **950**. Each spatial stream is then provided to a different antenna **920** via a separate transmitter **918**TX. Each transmitter **918**TX modulates an RF carrier with a respective spatial stream for transmission.

At the UE **950**, each receiver **954**RX receives a signal through its respective antenna **952**. Each receiver **954**RX recovers information modulated onto an RF carrier and provides the information to the receive (RX) processor **956**. The RX processor **956** implements various signal processing functions of the L1 layer. The RX processor **956** performs spatial processing on the information to recover any spatial streams destined for the UE **950**. If multiple spatial streams are destined for the UE **950**, they may be combined by the RX processor **956** into a single OFDM symbol stream. The RX processor **956** then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal comprises a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, is recovered and demodulated by determining the most likely signal constellation points transmitted by the eNB **910**. These soft decisions may be based on channel estimates computed by the channel estimator **958**. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the eNB **910** on the physical channel. The data and control signals are then provided to the controller/processor **959**.

The controller/processor **959** implements the L2 layer. The controller/processor can be associated with a memory **960** that stores program codes and data. The memory **960** may be referred to as a computer-readable medium. In the UL, the control/processor **959** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover upper layer packets from the core network. The upper layer packets are then provided to a data sink **962**, which represents all the protocol layers above the L2 layer. Various control signals may also be provided to the data sink **962** for L3 processing. The controller/processor **959** is also responsible for error detection using an acknowledgement (ACK) and/or negative acknowledgement (NACK) protocol to support HARQ operations.

In the UL, a data source **967** is used to provide upper layer packets to the controller/processor **959**. The data source **967** represents all protocol layers above the L2 layer. Similar to the functionality described in connection with the DL transmission by the eNB **910**, the controller/processor **959** implements the L2 layer for the user plane and the control plane by providing header compression, ciphering, packet segmentation and reordering, and multiplexing between logical and transport channels based on radio resource allocations by the eNB **910**. The controller/processor **959** is also responsible for HARQ operations, retransmission of lost packets, and signaling to the eNB **910**.

Channel estimates derived by a channel estimator **958** from a reference signal or feedback transmitted by the eNB **910** may be used by the TX processor **968** to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the TX processor **968** are provided to different antenna **952** via separate transmitters **954**TX. Each transmitter **954**TX modulates an RF carrier with a respective spatial stream for transmission.

The UL transmission is processed at the eNB **910** in a manner similar to that described in connection with the receiver function at the UE **950**. Each receiver **918**RX receives a signal through its respective antenna **920**. Each receiver **918**RX recovers information modulated onto an RF carrier and provides the information to a RX processor **970**. The RX processor **970** may implement the L1 layer.

The controller/processor **975** implements the L2 layer. The controller/processor **975** can be associated with a memory **976** that stores program codes and data. The memory **976** may be referred to as a computer-readable medium. In the UL, the control/processor **975** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover upper layer packets from the UE **950**. Upper layer packets from the controller/processor **975** may be provided to the core network. The controller/processor **975** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

FIG. **10** illustrates a wireless communications network **1000** that includes a plurality user equipments (UEs) (**1002**, **1006**, **1008**), and a plurality of evolved NodeBs (e.g., macro eNB **1102**, one or more neighboring cell eNBs).

The UEs (**1002**, **1006**, **1008**) may be associated with eNBs (**1004**) and/or directly associated with each other through D2D communications **1012**. The eNBs (**1004**, **1016**) may be associated with different cells. In the depicted aspect, UE **1002** is within the coverage area **1001** of macro eNB **1004** and may receive a broadcast **1010** from eNB **1004**. Further, UE **1002** may be directly associated with UE **106** through D2D communications **1012**. Devices in neighboring cells may be allocated different sets of resources for D2D communication. On Uplink (UL) subframes where are least part of the spectral resources are used for communications between the UEs and the macro eNB **1004**, the UEs (e.g., UE **1002**)) that are close to the macro eNB **1004** may reduce their data transmission power to protect the macro eNB **1004** physical uplink control channel (PUCCH) for use by legacy UEs **1008** to communicate **1014** with the macro eNB **1004**.

In operation, eNB **1004** may broadcast a fractional power control parameter that enabled UEs (e.g., UE **1002**, **1006**) may process to determine a maximum transmission power to use for D2D communications **1012**. In another optional aspect, one or more neighbor eNBs **1016** may each communicate a fractional power control parameter **1018** for broadcast **1010** by eNB **1004**. In one example aspect, wherein a macro eNB power saturation value is 65 dB, a margin needed to decode PUCCH when a UE transmits on non-PUCCH RBs may be defined in equation (1):

$$\text{Max. Power}=P^{PUCCH,edge}-PL^{max}+65\pm PL \quad (1)$$

In one aspect, eNB **1004** may generate the factional power control parameter (x) from equation (1) using equation (2):

$$x=\{(P^{PUCCH,edge}-PL^{max}+65) \quad (2)$$

As such, a wireless communications environment **1000** is described in which a fractional power control parameter may be used to reduce potential interference between an eNB **1004** and one or more legacy UEs **1008** from UEs **1002**, **1006** engaged in D2D communications **1012**.

FIG. **11** illustrates an example call flow diagram of a wireless communications system **1100** including an eNB **1102** and a plurality UES (**1104**, **1106**) that are operable to engage in D2D communications. Further, the system **1100** is operable to provide a factional power control parameter for a use by a UE within a threshold path gain of a macro eNB **1102** and engaged in D2D communications.

At act **1108**, UEs (**1104**, **1106**) may be engaged in direct D2D communications. At act **1110**, macro eNB **1102** may detect that UE(**1**) **1104** is within a threshold path gain of macro eNB **1102**. In one aspect, the path gain value used for the threshold may be dynamic and may depend at least in part of transmit power level perceived from UE(**1**) **1104**. Further, at act **1110** macro eNB may generate a factional power control parameter based on power of a physical uplink control channel (PUCCH) at an edge of a coverage area of the macro eNB, a maximum path loss value, and a macro eNB power saturation value. In one aspect, the macro eNB power saturation value may be a function of the power amplifier used by the macro eNB. In one aspect, the fractional power control parameter may be generated based on equations (1) and (2) as described above.

At act **1112**, the factional power control parameter may be transmitted to UE(**1**) **1104**. At act **1114**, UE(**1**) may calculate a maximum transmit power for D2D communications by determining a first minimum between the factional power control parameter plus a path loss value between the UE and the macro eNB and a maximum power used for the D2D communications. Such a calculation may be expressed in equation (3):

$$P^{D2D}=\min\{x+PL,P^{max}) \quad (3)$$

At act **1116**, the UE(**1**) **1104** may maintain transmit power levels at or below the value determined through equation (3). In one aspect, since UE(**1**) **1104** measures reference signals (RSs) transmitted by neighboring eNBs, the same formula may be applied (with path loss being based on estimated path loss) on subframes which are allocated for D2D in neighboring cells. The estimated path loss can be determined via measurement reports which are obtained by the UE even in RRC idle state. In another aspect, the UE may be configured to either apply power control as given in equation (3) for eNBs with a closed subscriber group (CSG) or to all eNBs detected via measurement reports. Further, in subframes that are not used for D2D transmissions in neighboring cells, UE(**1**) **1104** may use the factional power control parameter on UL subframes. In another aspect, if the DL subframe in neighboring cell is used for D2D, path loss based power control may be used. In one aspect, UE(**1**) **1104** may used fractional power control with a different constants to result in a more conservative maximum transmit power value since a UE on the cell edge may be receiver in the neighboring cell.

FIG. **12** is a flow chart **1200** of a method of wireless communication. The method may be performed by an eNB.

At block **1202**, the eNB may generate a fractional power control parameter based on a macro eNB power saturation value. In one aspect, the macro eNB power saturation value may be approximately 65 dB. In one aspect, the fractional power parameter may be generated by determining a first value by subtracting a maximum path loss value from a power of the PUCCH at the edge of the coverage area of the macro eNB and adding the macro eNB power saturation value to the first value.

In an optional, at block **1204**, the eNB may receive a fractional power control parameter for each of the one or more neighboring cells from each of the one or more neighboring cells.

At block **1206**, the eNB may broadcast the fractional power control parameter to prompt one or more UEs engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter. In one aspect, the D2D communications engaged in by the UEs are orthogonal in frequency to uplink communications received by the macro eNB from one or more other UEs. In an optional aspect, the broadcast may include a list including a fractional power control parameter for each of one or more neighboring cells. In such an optional aspect, inclusion of the one or more neighboring cells in the list depends on whether the one or more neighboring cells are a closed subscriber group cell, an open subscriber group cell, a macro eNB, a home eNB, a pico eNB, etc.

FIG. **13** is a conceptual data flow diagram **1300** illustrating the data flow between different modules/means/components in an exemplary apparatus **1004**. The apparatus **1004** includes a reception module **1302** that may receive various signals that allow apparatus to determine system performance values such as, but not limited to power of a physical uplink control channel (PUCCH) at an edge of a coverage area of the macro eNB **1304**, a maximum path loss value **1306**, etc. Further, in an optional aspect, reception module **1302** may receive a fractional power control parameter **1312** for each of the one or more neighboring cells from each of the one or more neighboring cells **1016**. In an optional aspect, the transmission module **1312** broadcast may include fractional power control parameter **1314** for each of one or more neighboring cells **1016**.

Apparatus **1004** further includes Power control parameter module **1308** that may be operable to generate a fractional power control parameter **1310** based on a macro eNB power saturation value. In one aspect, the macro eNB power saturation value may be approximately 65 dB. In one aspect, power control parameter module **1308** may generate the fractional power control parameter **1310** by determining a first value by subtracting the maximum path loss value **1306** from the power of the PUCCH at the edge of the coverage area of the macro eNB **1304**, and adding the macro eNB power saturation value to the first value.

Apparatus **1004** further includes transmission module **1312** that is operable to broadcast the fractional power control parameter **1310** to prompt one or more user equipments (UEs) **1002** engaged in device to device (D2D) communications to maintain a transmit power level below a power level based on the fractional power control parameter **1310**. In one aspect, the UEs **1002** engaged in D2D communications may be communicating orthogonal in frequency to uplink communications received by the macro eNB **1004** from one or more other UEs **1002**. In an optional aspect, the transmission module **1312** broadcast may include fractional power control parameter **1314** for each of one or more neighboring cells **1016**. In another optional aspect, transmission module **1312** may transmit the power control parameter for the cell to a neighboring cell **1016**.

The apparatus may include additional modules that perform each of the steps of the algorithm in the aforementioned flow charts FIGS. **11** and **13**. As such, each step in the aforementioned flow charts FIGS. **11** and **13** may be performed by a module and the apparatus may include one or more of those modules. The modules may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by a processor configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by a processor, or some combination thereof.

FIG. **14** is a diagram illustrating an example of a hardware implementation for an apparatus **1004'** employing a processing system **1414**. The processing system **1414** may be implemented with a bus architecture, represented generally by the bus **1424**. The bus **1424** may include any number of interconnecting buses and bridges depending on the specific application of the processing system **1414** and the overall design constraints. The bus **1424** links together various circuits including one or more processors and/or hardware modules, represented by the processor **1404**, the modules **1302**, **1308**, **1312**, and the computer-readable medium **1406**. The bus **1424** may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further.

The processing system **1414** may be coupled to a transceiver **1410**. The transceiver **1410** is coupled to one or more antennas **1420**. The transceiver **1410** provides a means for communicating with various other apparatus over a transmission medium. The processing system **1414** includes a processor **1404** coupled to a computer-readable medium **1406**. The processor **1404** is responsible for general processing, including the execution of software stored on the computer-readable medium **1406**. The software, when executed by the processor **1404**, causes the processing system **1414** to perform the various functions described supra for any particular apparatus. The computer-readable medium **1406** may also be used for storing data that is manipulated by the processor **1404** when executing software. The processing system further includes at least one of the modules **1302**, **1308**, and **1312**. The modules may be software modules running in the processor **1404**, resident/stored in the computer readable medium **1406**, one or more hardware modules coupled to the processor **1404**, or some combination thereof.

In one configuration, the apparatus **1004/1004'** for wireless communication includes means for generating a fractional power control parameter based on a macro eNB power saturation value, and means for broadcasting the fractional power control parameter to prompt one or more UEs engaged in D2D communications to maintain a transmit power level below a power level based on the fractional power control parameter. In one aspect, the D2D communications are orthogonal in frequency to uplink communications received by the macro eNB from one or more other UEs. In one aspect, the macro eNB power saturation value may be approximately 65 dB. The apparatus **1004/1004'** for wireless communication may further include means for determining a first value by subtracting the maximum path loss value from the power of the PUCCH at the edge of the coverage area of the macro eNB, and means for determining the fractional power control parameter by adding the macro eNB power saturation value to the first value. The apparatus **1004/1004'** for wireless communication may further include means for broadcasting a list including a fractional power control parameter for each of one or more neighboring cells. In one aspect, inclusion of the one or more neighboring cells in the list may depend on whether the one or more neighboring cells are a closed subscriber group cell, an open subscriber group cell, a macro eNB, a home eNB, a pico eNB, etc. The apparatus **1004/1004'** for wireless communication may further include means for receiving the fractional power control parameter for each of the one or more neighboring cells from each of the one or more neighboring cells.

The aforementioned means may be one or more of the aforementioned modules of the apparatus **1004** and/or the processing system **1414** of the apparatus **1004'** configured to perform the functions recited by the aforementioned means.

FIG. **15** is a flow chart **1500** of a method of wireless communication. The method may be performed by a user equipment (UE).

At block **1502**, the UE may receive a fractional power control parameter from a macro eNB while being engaged in D2D communications. In one aspect, the received factional power control parameter may include a fractional power control parameter for each of one or more neighboring cells. In one aspect, the fractional power control parameter may include a power of a PUCCH at the edge of the coverage area of the macro eNB less a maximum path loss value plus a macro eNB power saturation value.

At block **1504**, the UE may determine whether the a first value, defined by the fractional power control parameter plus a path loss value between the UE and the macro eNB, is less than a second value defined by a maximum power used for the D2D communications. In another aspect, the UE may determine a third value defined by the fractional power control parameter plus a path loss value between the UE and a neighboring cell eNB is less than the second value.

If, at block **1504**, the UE determines that the first value is not less than the second value, then at block **1506**, the UE may maintain transmission power levels for the D2D communications. Similarly, where a third value has been determined at block **1504** and where the UE determines that the third value is not less than the second value, the UE may maintain D2D communications transmission power levels. In such an aspect, the transmission power levels for D2D communications may be maintained for UL subframes associated with the neighboring cell. In another aspect, where a subframe is used for D2D communications in the cell is a DL subframe in a neighboring cell, a multiplier may be applied to the fractional power control parameter to result in a smaller value for the fractional power control parameter plus a path loss value between the UE and the macro eNB.

By contrast, if at block **1504**, the UE determines that the first value is less than the second value, then at block **1508**, the UE may reduce a maximum transmission power level for D2D communications to the first value. Similarly, where a third value has been determined at block **1504** and where the UE determines that the third value is not less than the second value, the UE may reduce a maximum transmission power level for D2D communications to the third value.

FIG. **16** is a conceptual data flow diagram **1600** illustrating the data flow between different modules/means/components in an exemplary apparatus **1002**. The apparatus **1002** includes a reception module **1602** that is operable to receive a fractional power control parameter **1604** from a macro eNB **1005** while being engaged in D2D communications with another UE **1006**. In one aspect, the fractional power control parameter **1604** may include a list of a fractional power control parameter for each of one or more neighboring cells.

The apparatus further includes a power control parameter analysis module **1608** that is operable to determine whether the a first value, defined by the fractional power control parameter **1604** plus a path loss value between the UE and the macro eNB **1004**, is less than a second value defined by a maximum power used for the D2D communications **1606**. Where power control parameter analysis module **1608** determines that the first value is greater than the second value, then the UE **1002** may maintain the transmit power that was being used for D2D communications. Where power control parameter analysis module **1608** determines that the first value is greater than the second value, then the power control parameter analysis module **1608** may use a reduced maximum transmission power level for D2D communications **1610**. In one aspect, power control parameter analysis module **1608** may determine whether a third value defined by the fractional power control parameter **1604** plus a path loss value between the UE **1002** and a neighboring cell eNB is less than the second value. In such an aspect, where power control parameter analysis module **1608** determines that the third value is greater than the second value, then the UE **1002** may maintain the transmit power that was being used for D2D communications. Further, in such an aspect, where power control parameter analysis module **1608** determines that the third value is greater than the second value, then the power control parameter analysis module **1608** may use a reduced maximum transmission power level for D2D communications **1610**. In another aspect, apparatus **1002** may be operable to determine that a subframe used for D2D communications in the cell associated with the macro eNB is a DL subframe in a neighboring cell, and power control parameter analysis module **1608** may be operable to apply a multiplier to the received fractional power control parameter to result in a smaller value for the fractional power control parameter plus a path loss value between the UE and the macro eNB.

The apparatus may further include a transmission module **1612** that is operable to assist in performing D2D communications. In one aspect, transmission module **1612** may engage in D2D communications using a maximum transmission power level **1610** determined by power control parameter analysis module **1608**.

The apparatus may include additional modules that perform each of the steps of the algorithm in the aforementioned flow chart FIGS. **11** and **15**. As such, each step in the aforementioned flow chart FIGS. **11** and **15** may be performed by a module and the apparatus may include one or more of those modules. The modules may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by a processor configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by a processor, or some combination thereof.

FIG. **17** is a diagram illustrating an example of a hardware implementation for an apparatus **1002'** employing a processing system **1714**. The processing system **1714** may be implemented with a bus architecture, represented generally by the bus **1724**. The bus **1724** may include any number of interconnecting buses and bridges depending on the specific application of the processing system **1714** and the overall design constraints. The bus **1724** links together various circuits including one or more processors and/or hardware modules, represented by the processor **1704**, the modules **1602**, **1608**, **1612**, and the computer-readable medium **1706**. The bus **1724** may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further.

The processing system **1714** may be coupled to a transceiver **1710**. The transceiver **1710** is coupled to one or more antennas **1720**. The transceiver **1710** provides a means for communicating with various other apparatus over a transmission medium. The processing system **1714** includes a processor **1704** coupled to a computer-readable medium **1706**. The processor **1704** is responsible for general processing, including the execution of software stored on the computer-readable medium **1706**. The software, when executed by the processor **1704**, causes the processing system **1714** to perform the various functions described supra for any particular apparatus.

The computer-readable medium **1706** may also be used for storing data that is manipulated by the processor **1704** when executing software. The processing system further includes at least one of the modules **1602**, **1608**, and **1612**. The modules may be software modules running in the processor **1704**, resident/stored in the computer readable medium **1706**, one or more hardware modules coupled to the processor **1704**, or some combination thereof.

In one configuration, the apparatus **1002/1002'** for wireless communication includes means for receiving, by a UE, a fractional power control parameter from a macro eNB while being engaged in D2D communications, and means for determining whether the a first value, defined by the fractional power control parameter plus a path loss value between the UE and the macro eNB, is less than a second value defined by a maximum power used for the D2D communications. Apparatus **1002/1002'** may include means for reducing a maximum transmission power level for D2D communications to the first value when the first value is determined to be less than the second value. In one aspect, apparatus **1002/1002'** may include means for determining whether a third value defined by the fractional power control parameter plus a path loss value between the UE and a neighboring cell eNB is less than the second value, and means for maintaining transmission power levels for the D2D communications when the third value is not determined to be less than the second value, or means for reducing a maximum transmission power level for D2D communications to the third value when the third value is determined to be less than the second value. In such an aspect, apparatus **1002/1002'** may include means for receiving a list including a fractional power control parameter for each of one or more neighboring cells. In such an aspect, the factional power control power selected from the list to be used to determine the third value may be based on a cell identifier of the neighboring cell eNB. In another aspect, the transmission power levels for D2D communications may be maintained for UL subframes associated with the neighboring cell. In one aspect, apparatus **1002/1002'** may include means determining that a subframe used for D2D communications in the cell associated with the macro eNB is a DL subframe in a neighboring cell, and means for applying a multiplier to the received fractional power control parameter to result in a smaller value for the fractional power control parameter plus a path loss value between the UE and the macro eNB. In one aspect, the fractional power control parameter may include a power of a PUCCH at the edge of the coverage area of the macro eNB less a maximum path loss value plus a macro eNB power saturation value.

The aforementioned means may be one or more of the aforementioned modules of the apparatus **1002** and/or the processing system **1714** of the apparatus **1002'** configured to perform the functions recited by the aforementioned means.

It is understood that the specific order or hierarchy of steps in the processes disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged. Further, some steps may be combined or omitted. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." Unless specifically stated otherwise, the term "some" refers to one or more. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

What is claimed is:

1. A method of wireless communications, comprising:

generating a fractional power control parameter based on a macro evolved nodeB (eNB) power saturation value; and

broadcasting the fractional power control parameter to prompt one or more user equipments (UEs) engaged in device to device (D2D) communications to maintain a transmit power level below a power level based on the fractional power control parameter.

2. The method of claim **1**, wherein the fractional power control parameter is further based on at least one of: power of a physical uplink control channel (PUCCH) at an edge of a coverage area of the macro eNB, or a maximum path loss value.

3. The method of claim **2**, wherein the generating the fractional power control parameter further comprises:

determining a first value by subtracting the maximum path loss value from the power of the PUCCH at the edge of the coverage area of the macro eNB; and

determining the fractional power control parameter by adding the macro eNB power saturation value to the first value.

4. The method of claim **1**, wherein the D2D communications are orthogonal in frequency to uplink communications received by the macro eNB from one or more other UEs.

5. The method of claim **1**, wherein the broadcasting further comprises broadcasting a list including a fractional power control parameter for each of one or more neighboring cells.

6. The method of claim **5**, wherein inclusion of the one or more neighboring cells in the list depends on whether the one or more neighboring cells are at least one of:

a closed subscriber group cell; an open subscriber group cell; a macro eNB; a home eNB; or a pico eNB.

7. The method of claim **5**, further comprising receiving the fractional power control parameter for each of the one or more neighboring cells from each of the one or more neighboring cells.

8. An apparatus for wireless communication, comprising:

means for generating a fractional power control parameter based on a macro evolved nodeB (eNB) power saturation value; and

means for broadcasting the fractional power control parameter to prompt one or more user equipments (UEs) engaged in device to device (D2D) communications to maintain a transmit power level below a power level based on the fractional power control parameter.

9. The apparatus of claim **8**, wherein the fractional power control parameter is further based on at least one of: power of a physical uplink control channel (PUCCH) at an edge of a coverage area of the macro eNB, or a maximum path loss value.

10. The apparatus of claim 9, wherein the means for generating the fractional power control parameter is configured to:

Determine a first value by subtracting the maximum path loss value from the power of the PUCCH at the edge of the coverage area of the macro eNB; and

Determine the fractional power control parameter by adding the macro eNB power saturation value to the first value.

11. The apparatus of claim 8, wherein the D2D communications are orthogonal in frequency to uplink communications received by the macro eNB from one or more other UEs.

12. The apparatus of claim 8, wherein the means for broadcasting is configured to broadcast a list including a fractional power control parameter for each of one or more neighboring cells.

13. The apparatus of claim 12, wherein inclusion of the one or more neighboring cells in the list depends on whether the one or more neighboring cells are at least one of:

a closed subscriber group cell; an open subscriber group cell; a macro eNB; a home eNB; or a pico eNB.

14. The apparatus of claim 12, further comprising means for receiving the fractional power control parameter for each of the one or more neighboring cells from each of the one or more neighboring cells.

15. An apparatus for wireless communication, comprising:

a processing system configured to:

generate a fractional power control parameter based on a macro evolved nodeB (eNB) power saturation value; and

broadcast the fractional power control parameter to prompt one or more user equipments (UEs) engaged in device to device (D2D) communications to maintain a transmit power level below a power level based on the fractional power control parameter.

16. The apparatus of claim 15, wherein the fractional power control parameter is further based on at least one of: power of a physical uplink control channel (PUCCH) at an edge of a coverage area of the macro eNB, or a maximum path loss value.

17. The apparatus of claim 16, wherein the processing system is further configured to:

determine a first value by subtracting the maximum path loss value from the power of the PUCCH at the edge of the coverage area of the macro eNB; and

determine the fractional power control parameter by adding the macro eNB power saturation value to the first value.

18. The apparatus of claim 15, wherein the D2D communications are orthogonal in frequency to uplink communications received by the macro eNB from one or more other UEs.

19. The apparatus of claim 15, wherein the processing system is further configured to broadcast a list including a fractional power control parameter for each of one or more neighboring cells.

20. The apparatus of claim 19, wherein inclusion of the one or more neighboring cells in the list depends on whether the one or more neighboring cells are at least one of:

a closed subscriber group cell; an open subscriber group cell; a macro eNB; a home eNB; or a pico eNB.

21. The apparatus of claim 19, wherein the processing system is further configured to receive the fractional power control parameter for each of the one or more neighboring cells from each of the one or more neighboring cells.

22. A non-transitory computer-readable storage medium stores instructions executable by one or more processors for:

generating a fractional power control parameter based on a macro-evolved nodeB (eNB) power saturation value; and

broadcasting the fractional power control parameter to prompt one or more user equipments (UEs) engaged in device to device (D2D) communications to maintain a transmit power level below a power level based on the fractional power control parameter.

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